MONTHLY WEATHER REVIEW.

Editor: Prof. Cleveland Abbe. Assistant Editor: Cleveland Abbe, jr.

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The Monthly Weather Review summarizes the current manuscript data received from about 3,500 land stations in the United States and about 1,250 ocean vessels; it also gives the general results of the study of daily weather maps based on telegrams or cablegrams from about 200 North American and 40 European, Asiatic, and oceanic stations.

The hearty interest shown by all observers and correspondents is gratefully recognized.

Acknowledgment is also made of the specific cooperation of the following chiefs of independent, local, or governmental services: R. F. Stupart, Esq., Director of the Meteorological Service of the Dominion of Canada; Señor Manuel E. Pastrana, Director of the Central Meteorological and Magnetic Observatory of Mexico; Camilo A. Gonzales, Director-General of Mexican Telegraphs; Capt. I. S. Kimball, General Superintendent of the United States Life-Saving Service; Commandant Francisco S. Chaves, Director of the Meteorological Service of the Azores, Ponta Delgada, St. Michaels, Azores; W. N. Shaw, Esq., Director Meteorological Office, London; Maxwell Hall, Esq., Government Meteorologist, Kingston, Jamaica; Rev. L. Gangoiti, Director of the Meteorological Observatory of Belen Collegel Havana, Cuba; Luis G. y Carbonell, Director, Meteorologica, Service of Cuba, Havana, Cuba; Rev. José Algué, S. J., Director of the Weather Bureau, Manila Central Observatory, Philippines; Maj. Gen. M. A. Rykachef, Director of the Physical Central Observatory, St. Petersburg, Russia; Carl Ryder, Director, Danish Meteorological Institute, Copenhagen, Denmark.

As far as practicable the time of the seventy-fifth meridian is used in the text of the Monthly Weather Review.

Barometric pressures, both at land stations and on ocean vessels, whether station pressures or sea-level pressures, are reduced, or assumed to be reduced, to standard gravity, as well as corrected for all instrumental peculiarities, so that they express pressure in the standard international system of measures, namely, by the height of an equivalent column of mercury at 32° Fahrenheit, under the standard force, i. e., apparent gravity at sea level and latitude 45°.

FORECASTS AND WARNINGS.

By Prof. E. B. Garriott, in charge of Forecast Division.

August opened with a storm of tropical origin near the North Carolina coast. The previous history of this storm is given in the Monthly Weather Review for July. During August 1 and 2 the center of disturbance moved northeastward near the middle Atlantic and New England coasts and past over or near New Foundland the night of the 2d. High barometric pressure over mid-ocean deflected the storm toward the high latitudes of the Atlantic.

The Virginian-Pilot, Norfolk, Va., of August 2, remarks as follows regarding warnings issued in connection with this storm:

> It was due to the magnificent work of the Weather Bureau that there were no wrecks along the coast. Many hours before the storm developed any great strength the Bureau had sent warnings along the coast to notify mariners that there was a blow off the Florida coast and advised caution about proceeding south. These warnings were sent to several wireless stations, which transmitted them to vessels at sea having the wireless apparatus, so that the news was flashed down the line.

The general weather conditions of the closing days of July and the first week in August conformed closely to the following forecast, that was issued July 29:

> There are no indications of a prolonged period of abnormal heat for any portion of the United States. A cool wave that now covers the Northwest will advance over the central valleys and the Lake region during the next three days. A barometric disturbance with rain will cross the country from about August 1 to 5, preceded by rising temperature, and followed by a period of lower temperature that will continue over the eastern districts during the latter half of next week.

The cold wave referred to advanced as forecast and reached the Atlantic coast August 1. The barometric disturbance reached the Atlantic States August 5. It was preceded by rising temperature, attended by rather well-distributed rains that were heavy in parts of the Ohio Valley, Tennessee, Mississippi, the lower Lake region, and the Middle Atlantic and New England States, and was followed by lower temperature that continued over the eastern districts during the balance of the week ending August 8.

The Times-Democrat, New Orleans, La., of August 3, comments on the forecast as follows:

> Professor Moore of the United States Weather Bureau, has commenced the issue of forecasts for periods of a week or more. The success which Professor Moore has achieved in his efforts to increase the efficiency of the Weather Bureau will cause the public to accept these forecasts with more confidence. The forecast issued July 29 for the succeeding ten days is being realized generally. The temperature which was between 70° and 80° over the northern portion of the country on the morning of July 30 was between 60° and 70°, as shown by the weather map issued yesterday. A disturbance with rain and preceded by warmer weather is expected to move across the country between August 1 and 5, and this is expected to be followed by cooler weather, which will continue over the eastern districts during the latter half of the week.
>
> Such forecasts show a marked step forward by the Weather Bureau, and are in line with the many improvements made in the weather service.

The Herald, Rochester, N. Y., of August 10, states:

> In this forecast, which predicted complicated weather conditions, including a warm wave which at that time did not appear on the weather map, Chief Moore made a perfect forecast.

Special forecasts were issued on the 9th and 13th. That of the 9th was in general terms. The forecast of the 13th specified the passage of a barometric disturbance from the Rocky Mountains to the Atlantic coast, from the 14th to 18th, that would be preceded by rising temperature, attended by copious rains that would cover the corn and spring wheat States, and followed by a period of lower temperature. The disturbance progressed as forecast and crost the Atlantic coast on the 18th. It was preceded by rising temperature that at points in the interior was the highest of the present season, was attended by copious rains in the corn and spring wheat States, and was followed by a several day period of temperature below the seasonal average.

The St. Louis Times, of August 15, refers editorially as follows to weather forecasts in general, and to the forecast of the 13th in particular:

> Close observers of weather conditions have noted in recent months that the Department of Meteorology at Washington has been indulging in some long-distance and wide-range forecasts.
>
> Time was when the word chiefly employed by the forecasters was "probably." Now there is a certain note of positiveness in the 24-hour

forecast, and the long-distance, wide-range bulletins amount almost to predictions. Several weeks ago, for instance, the department announced that a blanket of rain would begin at the Rocky Mountains and stretch to the Atlantic. The forecast covered a period of a week, gave great cheer to the agriculturalist and business man generally, and was fulfilled exactly.

Yesterday the department made a prediction, technically called a forecast, covering a period of five days, ending next Wednesday morning. All of the spring wheat and corn States are to have needed hot weather, followed by needed rain, after which it will be cooler. It will be worth while noting the outcome of this prediction.

If the Department at Washington finds it possible to make a forecast covering the great growing section of the country for a week, it will have increased its usefulness immeasurably.

A special feature of a forecast issued on the 18th, was a prediction of well-distributed rains in the cotton belt where rain was needed. The rains occurred over the cotton belt as forecast, and in the Atlantic States the rains that set in were exceptionally heavy.

The following from the Daily Picayune, New Orleans, of August 26, 1908, indicates the demand for weather information that increases with recognition of the value of the forecasts:

The weather map issued by the United States Weather Bureau yesterday showed generally settled weather conditions over the greater portion of the country for the first time in several days. These conditions call attention to the special forecast issued by Chief Willis L. Moore of the Weather Bureau, Tuesday, August 18, and published in the Picayune on the 19th. Looking over the weather map we see that the barometric depression referred to in the forecast crossed the Rocky Mountain districts on the 20th and 21st, the Plains States on the 22d, the central valleys and the Lake region on the 23d and 24th and is now over the Atlantic States. The well-distributed rains forecast by Professor Moore have fallen, and those sections of the cotton belt where rain was needed have received copious showers. The map issued Tuesday shows the comparatively cool and settled weather moving eastward just as forecast eight days ago. Forecasts of this character, when so fully verified as has been the case with the Weather Bureau forecasts, are of great importance to agricultural and commercial interests, and the public will look keenly for information telling a week or more in advance what weather to expect as they look for the daily forecasts covering a period of thirty-six to forty-eight hours. Commercial interests attach such importance to the forecast that request[1] has been made that such forecasts be telegraphed as soon as issued at the expense of the recipient.

The beginning of the third decade of the month showed the first signs of a breaking up of the summer distribution of atmospheric pressure over the Northern Hemisphere. From the 18th to 21st the barometer rose over the Siberian area and reached a reported reading of 30.18 inches at Irkutsk on the 21st. During the 21st and 22d the first frost-bearing cool wave of the summer advanced from the British Northwest Territory over extreme north-central portions of the United States.

On the 25th a period of unusually cool weather set in over the eastern portion of the United States and continued during the balance of the month. During this period the barometer was low over the British Isles and the Iceland area with readings below 29.00 inches over northern Scotland on the 27th and 29th. Pressure continued high over the eastern portion of the North American Continent and adjacent ocean, and from the 26th to 28th pressure was again high over the Siberian area. Over western-interior portions of the United States the barometer was falling gradually. At the close of the month abnormally low barometer over Great Britain and northwestern Europe was attended by severe gales over the North Sea and the British coasts.

BOSTON FORECAST DISTRICT.*

[New England.]

Rainfall was fairly well distributed and in excess of the normal, and temperature was slightly below the seasonal average. Maximum temperatures ranging from 80° to 90° occurred generally on the 13th to 14th, and minimum temperatures ranging from 32° to 55° were, with a few exceptions, noted on the 28th and 29th with scattered frosts from Massachusetts to Maine. There were no gales during the month.—*J. W. Smith, District Forecaster.*

[1] The request referred to was made by the New Orleans Cotton Exchange.

NEW ORLEANS FORECAST DISTRICT.*

[Louisiana, Texas, Oklahoma, and Arkansas.]

Moderate weather conditions prevailed and temperature was slightly above the normal. No general storms occurred along the west Gulf coast.—*I. M. Cline, District Forecaster.*

LOUISVILLE FORECAST DISTRICT.*

[Kentucky and Tennessee.]

Generous and beneficial rains occurred during the first half and drought conditions prevailed during the latter half of the month. Temperature averaged about normal and there were no devastating storms.—*F. J. Walz, District Forecaster.*

CHICAGO FORECAST DISTRICT.*

[Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, and Montana.]

Precipitation, mostly in the form of local showers, was well distributed. No storm warnings were ordered and no conditions occurred that justified their display. A notable feature was the frosts that occurred in North Dakota, Minnesota, and Wisconsin from the 20th to 24th. The frosts were light and not of a character to cause serious damage, except in the cranberry marshes of Wisconsin where killing frost was reported on the 20th, 23d, and 24th. Timely warnings had been sent and the marshes were flooded, so that no damage occurred. The Milwaukee, Wis., Sentinel commented on the warnings as follows:

Prompt action on the part of the Weather Bureau has saved the cranberry crop of Wisconsin, and the first frost of the season last night failed in its apparent effort to ruin an important part of the Thanksgiving dinner. Major Hersey, who is temporarily in charge of the Chicago office, has been at the Milwaukee station several seasons and during that time has learned the importance of the Wisconsin cranberry crop. Accordingly when the temperature dropped off in the Dakotas night before last he began to watch things closely. Yesterday morning it became evident that the cold weather was spreading down into Wisconsin. Warnings were accordingly sent out to the marshes, and this morning, though there had been a distinct frost across the belt, it was announced that the crop was safe. In all the marshes floodgates are kept ready for just such a warning, and the moment word was received of the approaching frost water began to run out over the acres and acres of berry land.

H. B. Hersey, Inspector and District Forecaster.

DENVER FORECAST DISTRICT.*

[Wyoming, Colorado, Utah, New Mexico, and Arizona.]

The month was cool, with an excess of rainfall, and in localities the rainfall was heavy. From the 25th to the close of the month the weather was fair, with low night temperatures. Killing frost occurred the morning of the 31st in portions of Wyoming and northwestern Colorado.—*P. M. McDonough, Local Forecaster, temporarily in charge.*

SAN FRANCISCO FORECAST DISTRICT.†

[California and Nevada.]

The present August was not an abnormal month. Thunder-storms were frequent from the 3d to 6th in the high Sierra, and in the Valley of the Colorado. Rain from a disturbance of the Sonora type occurred from the 8th to 10th. A series of reports by wireless was received from the Pacific fleet under command of Admiral Swineburne. These were valuable and were utilized in the forecasts. There were no frost nor storm warnings issued.—*A. G. McAdie, Professor and District Forecaster.*

PORTLAND, OREG., FORECAST DISTRICT.†

[Oregon, Washington, and Idaho.]

The month was quiet, and storm warnings were neither issued nor required. Temperature averaged slightly below normal and there was about the usual amount of rainfall.

* Morning forecasts made at district center; night forecasts made at Washington, D. C.

† Morning and night forecasts made at district center.

Numerous small forest fires occurred until the 25th when light but general rains cleared the atmosphere. Light frosts were reported in exposed places in extreme eastern Oregon and in southern Idaho on the 26th, 30th, and 31st, for which warnings were, as a rule, issued in time to be of service.—*E. A. Beals, District Forecaster.*

RIVERS AND FLOODS.

Disastrous floods occurred during the last decade of August in the rivers of Georgia, North Carolina, and South Carolina, and a flood of moderate proportions prevailed in the James River coincident with the floods in Georgia and the Carolinas. The floods were attributable to heavy and widespread rains over the States drained by these rivers, and more especially to the heavy rains in the southern Appalachian Mountains, where these rivers have their sources. Warnings were issued well in advance of the floods and resulted in the saving of many lives and the protection of much movable property. The following editorial is taken from the Baltimore American of August 28, 1908:

Augusta has been visited by the sweep of the tempest, the storms Wednesday and Thursday making wide wreckage and creating tremendous losses in the southern city. There is naturally a great deal of suffering attending the destruction of property and commodity values, estimated at a million dollars. Hundreds of persons are homeless and many have been thrown out of employment. The Savannah River played havoc with the property lining its banks. Its overflow inundated the city and caused the citizens to take to the boats provided for their rescue.

The value of the Weather Bureau to flood-threatened communities was shown in the warnings issued Tuesday morning that the river, by the following evening, would rise 35 to 37 feet. The citizens, thus forewarned, took to the hills, and many saved their household effects by acting on the prediction. It seems that the flooding of Augusta was aggravated by the system of water supply, consisting of a series of canals and dams in the hills above the city, which thus conveyed the water for the consumption of the people, as well as to supply power for the cotton mills. The overflowing of the central supply caused these canals to become sluices, through which the water poured into the city in great volume.

Throughout Georgia and adjacent States great damage has been done the crops. * * *

Reports in detail concerning these floods follow.

Rivers in other parts of the country were not in flood at any time during the month. As a matter of fact, unusually low stages were prevalent in a number of rivers, the water being so low as to interfere with navigation.

FLOOD IN THE SAVANNAH RIVER.

By D. FISHER, Official in Charge, Local office, Weather Bureau, Augusta, Ga.

The greatest and by far the most destructive flood in the history of this section occurred August 26–27, 1908, which was 0.1 foot higher than the memorable freshet of September 11, 1888.

On the 24th special reports from rainfall and river stations in this district showed the following amounts of rainfall, viz: Anderson, S. C., 5.50 inches; Calhoun Falls, S. C., 4.25 inches; Carlton, Ga., 5.64 inches; Washington, Ga., 0.15 inch, and Greenwood, S. C., 2.46 inches. The river gage at Augusta indicated 11.9 feet.

On the morning of the 25th the river at Augusta had risen to 22.3 feet, and the following rainfall reports were received, viz: Anderson, 5.50 inches; Calhoun Falls, 3.65 inches; Washington, 1.28 inches. Based upon these data, a river forecast was issued announcing a maximum stage of 33 feet in the next twenty-four hours, which was mainly intended for and distributed to the farmers in the lowlands below Augusta, since no damage from this stage would be anticipated at this city. At 10:30 a. m. of the 26th, a forecast was issued stating that the river at Augusta would in all probability reach 36 feet. The following warning was disseminated at 11 a. m.:

Supplemental forecast issued 10:30 a. m., placing the maximum stage at 38 feet by midnight; entire city likely to be submerged by midnight.

At the time of sending the telegram above referred to the water was entering the city, and at noon was rushing thru the streets like a mill race, finally submerging the city, and reaching the highest stage of 38.8 feet about 2 a. m., August 27. The river remained at a stand for about three hours and on the following morning the water had fallen to 33 feet at which stage the flood-stricken people were able to leave their homes. The freshet exceeded the flood of September 11, 1888, by 0.1 foot.

In this connection it is proper to state that all that human effort could do was accomplished by means of the telephone, and, thru advice given, many merchants were able to protect their goods which otherwise would have been ruined. When the water was coming over Broad street, at noon of the 27th, those who were in the stores engaged in saving their property had great difficulty in reaching their homes in safety.

A conservative estimate places the damage as follows, viz:

Money value of property destroyed or damaged, including railroads, etc	$1,000,000
Money value of crops destroyed	50,000
Damage to farm lands by erosion or deposit	10,000
Money value of losses occasioned by enforced suspension of business, including wages of employees, such as causing a shut-down of the four large cotton mills here for a period of at least three months	60,000
Money value of property saved by flood warnings	50,000

FLOODS IN THE OCMULGEE AND OCONEE RIVERS.

By W. A. MITCHELL, Official in Charge, Local Office, Weather Bureau, Macon, Ga.

On the 25th heavy rains occurred over central and northern Georgia. In the basins of the Ocmulgee and Oconee rivers the following rainfalls in inches were reported on the morning of the 25th: Atlanta, 0.76; Griffin, 1.40; Covington, 2.00; Greensboro, 2.36; and Athens, 8.17. The river stage at Macon the morning of the 22th was 11.8 feet and at Milledgeville, 8.9 feet.

The following warning was issued at 8:20 a. m. of the 25th:

Moderate rise expected in the Ocmulgee River to-day, reaching a stage of probably 14.0 feet at Macon. Considerable rise expected in the Oconee, but not to flood stage.

But later in the day a heavy rain of 2.80 inches fell at Macon and vicinity and 1.65 at Athens, and smaller amounts at other points in the upper basin. By 4 p. m. the stage at Macon was 16.7 feet, and at Milledgeville 15.2 feet.

The following warning was then issued:

Continued rains in the basin of the Ocmulgee and Oconee rivers will cause a rise to or near flood stage in both streams.

At 5:30 p. m., the Ocmulgee at Macon had reached 17.5 feet and was still rising. It evidently went near 18 feet during the night, from appearances along the bank the next morning.

The Oconee at Milledgeville at 7 a. m. of the 26th was 24.8 feet, rising. The only rainfall of importance then reported in the Oconee Basin was 1.32 inches at Greensboro. At 3 p. m. the stage at Milledgeville was 29.4 feet, rising, and the following forecast was issued:

Flood crest past Macon last night with a stage of 18 feet; it will reach Abbeville September 1 with a stage of about 14 feet. The Oconee was 29 feet at Milledgeville to-day; this rise will reach Dublin August 30 with stage of about 20 feet.

On the morning of the 27th reports showed a stage of 33.2 feet at Milledgeville and the river was still rising. An advisory warning was accordingly issued to residents in the Oconee Valley to prepare for extreme high water. A report at 3 p. m. showed 32.8 feet and falling. This flood crest reached Dublin on August 30, with a stage of 23.2 feet. The crest of the rise in the Ocmulgee reached Hawkinsville on August 31, with a stage of 12.3 feet; Abbeville on September 2, with a stage of 11.6 feet and Lumber City on September 6, when a height of 9.5 feet was noted.

Some damage resulted from the flood in the upper course of the Oconee, from Milledgeville to Athens. Several bridges and factories were damaged and some cattle lost. In the Omulgee the flood proved to be a blessing to the navigation interests on the river, the boats having been tied up and idle

for some time because of low water. No damage resulted from the rise in this stream.

FLOOD IN THE JAMES RIVER.

By E. A. Evans, Official in Charge, Local office, Weather Bureau, Richmond, Va.

The rise in the James River, covered by a warning issued on the night of August 23, was preceded by about thirty-six hours of practically uninterrupted rainfall. At intervals the fall was heavy, and generally thruout the watershed the measured amounts reported were abnormal. When the rains set in the river was at stages of zero and below.

By Tuesday night, August 25, the run-off began to show in streams tributary to the James River, and by the morning of the 26th there was a rapid and general rise in that part of the basin east of Lynchburg. At Columbia, Va., the 8 a. m. gage reading was 15.6 feet, and at Richmond 8.8 feet. The subsequent rise at Columbia to the maximum stage of 19.3 feet, was slow, but at Richmond the rate of increase until a stage of 8.2 feet occurred was rapid, averaging 0.7 foot an hour. During the entire day and well into the night the river rose steadily, reaching a maximum stage after midnight of the 26th and then coming to a stand, after which it fell slowly.

The evening of the 25th, warnings of moderate freshet conditions for the lower basin, Scottsville to Richmond, were issued, and telegraphic advices sent to Scottsville and Columbia. Notification was also given by telephone to the Chesapeake and Ohio train despatcher for transmission to other points on the James River division, to the local press and to such of our flood-warning list as could be reached by that means. The warning for Richmond was for a 12-foot rise and was very generally heeded, the steamboat lines removing freight from their lower dock freight sheds, the street car lines preparing for interruption to their service at Lester street, and other interests likely to be affected taking necessary precautions. During the afternoon of the 26th the steamboat docks went under water, and before night street car service was broken at Lester street. This condition lasted thru the night and until the mid-afternoon of the 27th.

The money value of property destroyed or damaged, exclusive of crops, was about $3,000, so far as known, the property being loose timber and false timber work used in repairing the Free Bridge, Richmond to Manchester.

No figures are at hand for an estimate of the value of crops destroyed, or of damage to farm lands, altho the newspapers report it as heavy, or of loss occasioned by enforced suspension of business, if any.

The value of goods placed beyond the reach of damage thru the warnings was about $5,000.

FLOOD IN THE SANTEE RIVER WATERSHED.

By J. W. Bauer, Official in Charge, Local office Weather Bureau, Columbia, S. C.

The following is the report of the Santee River and its confluent tributaries, namely the Congaree, formed by the Broad and Saluda rivers, and the Wateree-Catawba system.

The rainfall that made this possibly the most disastrous flood in the history of South Carolina, began on August 23 and continued in the form of heavy showers, and in places as continuous rain, until the morning of the 26th, having been exceptionally heavy at a number of places, principally in the foothills of the Appalachians, in the form of a belt of country varying from 30 to 80 miles in width, and extending from northern Georgia thru South Carolina, North Carolina, and Virginia.

For the five days ending August 27, the following rainfalls, in inches, were reported: Anderson, S. C., 14.82; Greenville, S. C., 16.94; Catawba, S. C., 10.82; Santuc, 11.33, and Mount Holly, N. C., 11.41. A fall of 9.05 inches in twenty-three hours occurred at Camden, S. C., on the 25-26th.

Excessive rains began at places on the 23d, and were general over the watersheds of the Congaree and Wateree rivers on the 24-25th and at a few places on the 26th. There had been quite heavy rains over the same region from the 19th to the 21st, inclusive, that had nearly saturated the soil, so that the run-off from the following week's rains was more than normal.

The effect can best be shown by the following table of river stages. At some of these stations it was impracticable to secure readings, owing to the fact that the river gages were lost, and there was no exact method or even approximate marks by which to estimate the height of the water.

Table 1.—*River stages in South Carolina during August, 1908, in feet.*

Date.	Pelzer, S. C.	Chappells, S. C.	Blairs, S. C.	Columbia, S. C.	Mt. Holly, N. C.	Catawba, S. C.	Camden, S. C.	Rimini, S. C.	Ferguson, S. C.
August 23	4.2	2.9	1.8	1.4	4.6	8.3	16.1	10.7	11.5
August 24	5.4	12.9	10.8	3.3	4.8	10.2	19.4	11.5	11.5
August 25	25.6	16.8	22.0	21.2	10.0	28.4	29.0	12.4	11.7
August 26	14.0	34.7	31.1	26.6	14.2	28.0	39.7	12.9	12.2
August 27	9.8	......	31.0	35.8	12.0	28.0	38.4	13.3	12.4
August 28	5.8	......	23.0	34.7	5.0	20.0	35.2	22.4	13.0
August 29	5.6	......	10.0	22.7	3.0	12.0	32.6	31.7	14.7
August 30	5.1	......	4.2	14.5	2.8	5.0	21.0	33.8	21.5
August 31	4.7	......	2.2	7.3	2.8	4.5	16.5	32.0	23.7

Advisory and cautionary warnings were issued on the night of the 23d, and the next morning warnings were issued for the Wateree River with the information that the river would rise above flood stage in the next twenty-four hours. On the morning of the 25th all interested persons in the Congaree, Wateree, and Santee valleys were warned to get all movable property on high ground as an unusual flood was imminent. Warnings were issued for a stage of 28 feet at Columbia and 32 feet at Camden, and later in the afternoon a statement was given to the paper stating that the present flood would probably exceed those stages.

No movable property would have been lost if the owners had heeded the advice of this office to remove live stock to high ground, but, relying on the previous high-water marks and not believing that these would be exceeded, a number of cattle and horses were lost. The inhabitants or planters of the Santee River Valley were warned in ample time and the loss of live stock was avoided.

Losses by flood in South Carolina.

Value of property destroyed, excluding crops	$571,800
Value of crops destroyed	312,200
Damage to farm land by erosion or deposit	177,800
Suspension of business of employees	82,000
Total loss	$1,143,800

Money value of property saved by warnings of the Weather Bureau, $56,000.

Heavy rains almost without interruption from August 14 to 27, caused floods in eastern North Carolina.

The Roanoke River began to rise on the 23d. From the 24th to the 27th it rose approximately 10 feet a day to a maximum stage of 45.7 feet during the night of the 27th–28th. The floods in the Roanoke were not so disastrous as those in other portions of the State, but there was, however, an immense loss of property.

The Tar River rose slowly to a maximum stage of 19.4 feet on September 2, but did not reach the flood stage.

The worst floods occurred in the valley of the Cape Fear River. This river reached a maximum stage of 67.5 feet at Fayetteville, N. C., on August 29, which was higher than ever before recorded. Warnings were issued in advance of this flood to the effect that the river would reach a stage of 66 feet. The damage by floods along the river was very large, many county bridges being washt away and some railroad bridges threatened. The river flooded all the lowlands, a portion of the city of Fayetteville, and caused much suffering and material loss.

The highest and lowest water, mean stage, and monthly range at 212 river stations are given in Table IV. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*E. H. Bowie, Local Forecaster.*

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

ANNUAL RISE OF THE COLUMBIA RIVER IN 1908.[1]

By E. A. Beals, District Forecaster. Dated Portland, Oreg., August 26, 1908.

As is well known the annual rise of the Columbia River is almost wholly due to the melting of the winter's snow in the mountains and foot hills within the Columbia River drainage basin.

The following table shows the highest water and the date of its occurrence this year at all stations on the Columbia River and its principal tributaries:

Table 1.—*Flood crests, Columbia watershed, 1908.*

Stations.	Height.	Date.
	Feet.	
Bonners Ferry	27.8	June 10 and 11.
Newport	21.7	June 16, 17, 18, and 19.
Lewiston	14.1	June 15 and 16.
Wenatchee	41.0	June 18.
Umatilla	21.9	June 17 and 18.
Celilo	19.1	June 18.
The Dalles	37.1	June 18.
Cascade Locks	29.6	June 19.
Vancouver	22.4	June 21.
Riparia	13.7	June 17.
Portland	21.2	June 20 and 21.

The accompanying hydrograph, fig. 1, shows the behavior of the river at Wenatchee, Wash., 200 miles above the junction of the Columbia and the Snake rivers; at Lewiston, Idaho, on the Snake River, 200 miles from its mouth; and at Vancouver, Wash., about 100 miles from the mouth of the Columbia.

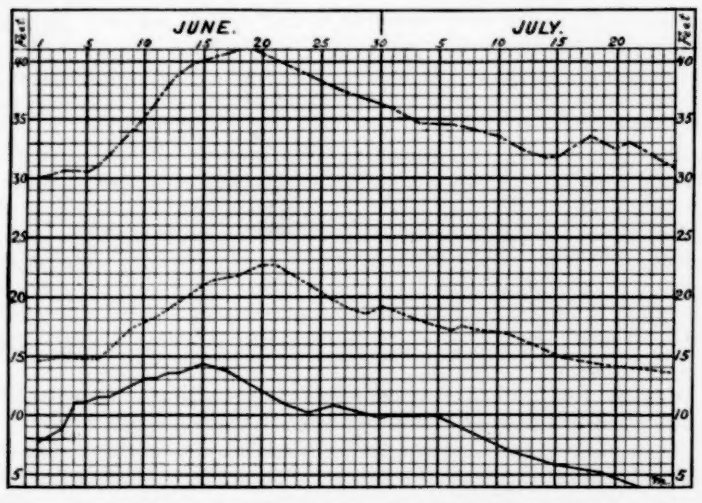


Fig 1.—Hydrographs of daily stages on the Columbia and Snake rivers.
- - — - Columbia River, at Wenatchee, Wash.
- - - - - - Columbia River, at Vancouver, Wash.
——— Snake River, at Lewiston, Idaho.

As compared with last year, the rise this year was about two feet higher in the lower stretch of the river where the width was normal. The rise also occurred about twelve days later than last year. It overflowed the bottom lands to a depth of about five feet for 20 miles on either side of Vancouver. All the lower docks of the city of Portland were flooded, as well as the cellars along the water front. Forecasts of this flood were begun on May 20 and continued until July 12. They were very accurate, and the high water did no damage except such as resulted from the flooding of a small amount of cultivated ground.

[1] This report was received too late for insertion in the July Monthly Weather Review.

For comparative purposes the best record of the temperature and precipitation over the drainage basin of the upper Columbia and the Snake rivers is that given monthly by Table I of the Monthly Weather Review, under the subheading Northern Plateau. The average precipitation and mean temperatures together with the departures from normal in that district for November and December, 1907, and for January, February, and March, 1908, are given in Table 2.

Table 2.—*Temperature and precipitation of northern Plateau during cold season 1907–8.*

Year and month.	Temperature.		Precipitation.	
	Mean.	Departure.	Average.	Departure.
1907.	°F.	°F.	*Inches.*	*Inches.*
November	41.6	+2.9	0.89	−0.5
December	34.8	+2.7	2.12	+0.4
1908.				
January	32.7	+3.9	0.76	−0.9
February	35.2	+3.1	1.13	−0.4
March	41.7	+1.5	0.95	−0.6
	37.2	+2.8	5.85	−2.0

This table shows that the precipitation was about 2 inches short of the normal, but during November and December, 1907, the amount was nearly normal. The snow that fell during this time packed solidly, and at the end of March the special reports regarding the winter's snowfall showed that about the normal amount had fallen in British Columbia, northern Idaho, and western Montana, while in southern Idaho and northern Wyoming there was a slight deficiency. The temperature during the entire snow season was uniformly above normal. Taking these conditions alone into consideration, a moderate rise only could be expected, which would occur a little later than usual on account of the snow being so solidly packed.

The determining factor in this flood crest which recurs each year is not so much the amount of snow that falls as the way it melts in the spring. If the mean temperature during April is above normal, and this month is followed by a mild May, the rise unusually comes earlier, and is not apt to bring very high water. If, however, the spring is backward, and a long hot spell occurs in May, then the snow melts rapidly and high water follows. This year we had a warm April in the mountains with the temperature about 2° above normal, but May was cold and very little snow melted during that month. Consequently, when the warm weather of June came the snow melted quickly resulting in a flood crest about 2 feet higher, and nearly two weeks later than last year.

Table 3.—*Flood crest at Portland, Oreg., during the annual rise of Columbia River.*

Year.	Stage.	Year.	Stage.	Year.	Stage.	Year.	Stage.
	Feet.		*Feet.*		*Feet.*		*Feet.*
1879	19.3	1887	25.7	1895	16.3	1903	24.0
1880	27.3	1888	18.2	1896	23.8	1904	20.8
1881	19.7	1889	10.0	1897	23.7	1905	13.6
1882	26.1	1890	20.1	1898	20.7	1906	13.4
1883	17.8	1891	14.1	1899	24.2	1907	19.2
1884	20.2	1892	19.3	1900	17.8	1908	21.2
1885	14.5	1893	22.0	1901	20.8		
1886	20.0	1894	33.0	1902	20.7		

For purpose of comparison, there is submitted Table 3, showing the stages of all the recorded flood crests at Portland, Oreg., due to the annual rise in the Columbia River.

THE 1907 ANNUAL RISE IN THE COLUMBIA RIVER.

Mr. E. A. Beals, district forecaster, submits under date of August 26, 1908, the following corrections to his report on the 1907 annual rise in the Columbia River, as published in the MONTHLY WEATHER REVIEW for July, 1907, XXXV, page 305:

For Table 1, substitute the following table:

Northern Plateau.—Temperature and rainfall.

	Temperature.		Rainfall.	
	Mean.	Departure.	Average.	Departure.
1906.	°	*Inches.*	*Inches.*	*Inches.*
November	36.0	−0.9	1.91	+0.5
December	35.9	+3.6	2.54	+0.7
1907.				
January	24.4	−2.3	1.91	−0.1
February	38.4	+6.9	1.84	+0.2
March	41.3	+1.1	2.22	+0.5
	35.2	+1.7	10.42	+1.8

In the second paragraph of the first column of page 305, change the second word from "total" to "average." Change the third and fourth paragraphs of the same column to read as follows:

"It will be seen by this table that last year during the period of snowfall there was 1.8 inches excess in precipitation, and an excess of 1.7° in temperature. Reports gathered at the end of March from snowfall reporters in western Montana, British Columbia, Idaho, and northwestern Wyoming, were to the effect that there was more than the average amount of snow on the ground at that time, and if the amount of snow in the mountains is a gage for the height of the subsequent flood crest, then unusually high water was to be expected later on."

"The mean temperature in the northern Plateau during April and May, 1907, was nearly normal, being only 0.8° below normal in April and 0 9° above normal in May. Also during these months there were no unusual or protracted hot spells, but, instead, the variations from day to day were quite small and uniform."

STORMS AND ICE ON THE GREAT LAKES.

By NORMAN B. CONGER. Dated Detroit, Mich., July 11, 1908.

THE DISPLAY OF STORM WARNINGS ON THE GREAT LAKES.

The storm-warning flags adopted by the Weather Bureau for announcing the approach of wind-storms are as follows:

The storm warning (a red flag 8 feet square, with black center 3 feet square) indicates that the storm is expected to be of marked violence.

The red pennant (8 feet hoist and 15 feet fly) displayed with flags indicates easterly winds; that is, from northeast to south, inclusive, and that the storm center is approaching.

The white pennant (8 feet hoist and 15 feet fly) displayed with flags indicates westerly winds; that is, from north to southwest, inclusive, and that the storm center has past.

When the red pennant is hoisted *above* the storm-warning flag, winds are expected from the northeast quadrant; when *below*, from the southeast quadrant.

When the white pennant is hoisted *above* the storm-warning flag, winds are expected from the northwest quadrant; when *below*, from the southwest quadrant.

Night storm warnings.—By night a red light will indicate easterly winds; a white light *below* a red light will indicate westerly winds.

The hurricane warning (two storm-warning flags, red with black centers, displayed one above the other) indicates the expected approach of tropical hurricanes, and also of those extremely severe and dangerous storms which occasionally move across the Lakes and the northern Atlantic coast.

When orders to hoist this warning are received at any Weather Bureau station, every effort will be made by the officials and employees of the service to give the warnings the widest possible distribution, and all vessels will be notified that it is dangerous to leave port.

The regular Weather Bureau stations on or near the Great Lakes are designated by small capitals in the following lists. They are:

Lake Superior.—Duluth, Minn.; Houghton and Marquette, Mich.

St. Marys River.—Sault Sainte Marie, Mich.

Lake Michigan.—Green Bay and Milwaukee, Wis.; Chicago, Ill.; Escanaba and Grand Haven, Mich.

Lake Huron.—Alpena and Port Huron, Mich.

Detroit River.—Detroit, Mich.

Lake Erie.—Toledo, Sandusky, and Cleveland, Ohio; Erie, Pa.; and Buffalo, N. Y.

Lake Ontario.—Rochester and Oswego, N. Y.

Storm and hurricane warnings are displayed at all regular Weather Bureau stations, and at a number of smaller ports, designated as storm-warning stations, in charge of displaymen, who hoist the warnings and post and distribute the bulletins, giving information of the storms on the Great Lakes.

At all lake stations, except Port Huron, Mich., a chart is issued daily, except Sundays, showing the weather conditions at 8 a. m., seventy-fifth meridian time (7 a. m., Central time), over the region of the Great Lakes and to the westward. Port Huron, Mich., is supplied with charts from Detroit. Vessel masters are cordially invited to call at any of the Weather Bureau offices for these charts or any other information they may desire in connection with the weather. The official in charge of the Weather Bureau office at Detroit, Mich., has been instructed to furnish a copy of all storm warnings, in addition to the weather maps, for use of vessel masters passing Detroit. Arrangements have been made with the Post-Office Department whereby these warnings and weather maps will be delivered to the masters by the mail boat. In case the mail boat does not have mail for each boat and the master desires information of the latest weather conditions, the following code of signals promulgated by the postmaster at Detroit may be used:

Signal to passing boats from United States mail boat for delivery of mail: (Blasts) one long (————); one short (——); one long (————).

Signal to steam vessels wanting mail boat to call for mail: (Blasts) one long (————); one short (——): one long (————).

Signals for sailing vessels requiring mail boat: White flag by day. Flashing bright light at night.

Signal from mail boat to large boat to check down: Three blasts from mocking-bird whistle.

Signal from rowboat belonging to mail boat when approaching vessels for delivery of mail: White flag in daytime. Swinging bright light at night.

For ordinary storm warnings the mail boat will display a red flag with a black square center; and for warnings of severe or dangerous storms, two flags, red with black square centers. In the latter case the mail boat will deliver storm warnings to *all boats bound down*.

The Kendall Reporting Agency, at Port Huron, Mich., will deliver storm warnings to boats *passing into Lake Huron*.

Storm-warning displaymen at stations on the Great Lakes are authorized to telegraph for information regarding expected weather conditions in their vicinity whenever such information is requested by masters flying the American flag. From stations on Lake Superior, Michigan, or Huron these requests will be addrest to the Weather Bureau office, Chicago; from

stations on Lake Erie or Ontario to the Weather Bureau office, Buffalo.

Masters of vessels of this class, whenever at a port on the Great Lakes where there is no Weather Bureau office or storm-warning station, may themselves telegraph for this information, observing the same rule as to territory as given above.

The telegram should be addrest: "Weather, Chicago," or "Weather, Buffalo."

These messages and the answers thereto will be at Government expense, but it is expected that the privilege thus granted will only be exercised when the information sought is regarded as necessary for the safety of the vessels concerned.

It is also expected that vessel masters who avail themselves of this privilege will make public the information obtained for the benefit of all vessels in their vicinity.

LIST OF STATIONS AND LOCATION OF FLAGSTAFFS AND TOWERS.[1]

LAKE SUPERIOR.

Ashland, Wis.—J. G. Upthegrove.

Steel tower: Bay front, foot of Second avenue, W., near junction with Front street. Electric lights.

Bayfield, Wis.—William Miller.

Steel tower: Sixty-five feet from water's edge, facing First street; 120 feet from intersection with Front avenue. Electric lights.

Deer Park, Mich., life-saving station.—Sara E. McGaw.

Flagstaff: Deer Park Life-saving station, near mouth of Sucker River.

Duluth, Minn.—W. H. Richardson, local forecaster.

Displays: Flags and electric lights.

Steel tower: Southwest side of Weather Bureau Building, Seventh avenue, W., and Eighth street.

Flags: Post-office Building, First street and Fifth avenue, West Duluth. Evening Telegraph Building, 1017 Tower avenue, West Superior.

Eagle Harbor, Mich.—Alice Nolen.

Steel tower: On light-house reservation.

Grand Marais, Mich.—Mrs. Lena Truedell.

Steel tower: On Life-Saving Service reservation. Electric lights.

Houghton, Mich.—Abe Wiesner, observer.

Steel tower: On roof of Weather Bureau office, Sheldon Building. Electric lights.

Marquette, Mich.—H. R. Patrick, observer.

Steel Tower: Marquette County Savings Bank Building, southeast corner of Washington and Third streets. Electric lights.

Munising, Mich.—A. C. Hortho.

Steel tower: In Beach Inn yard, just east of Beach Inn.

Ontonagon, Mich.—A. S. Follansbee.

Flagstaff: On Court House lawn.

Pequaming, Mich.—Charles Hebard & Son.

Flagstaff: Two hundred feet north of Hebard & Son's sawmill.

Ship Canal, Mich., life-saving station.—Mrs. C. E. McCormick.

Steel Tower: At Lake Superior end of ship canal.

Sault Sainte Marie, Mich.—Alexander G. Burns, observer.

Flagstaff: Weather Bureau Building. Electric lights.

Weather maps and storm-warning messages are placed in the canal office for masters of boats passing the canal, also with the superintendent of the Canadian Soo Canal. Barometers adjusted.

Superior, Wis.—E. A. Ostergren.

Steel tower: On outer end of Dock No. 2.

Two Harbors, Minn.—G. W. Watts.

Steel tower: At Ore Dock No. 2 and flagstaff at store of J. Schreiner & Co., corner of Poplar street and First avenue. Electric lights.

[1] This list has been revised to July 1, 1908.

Washburn, Wis.—Joseph A. McItree.

Steel tower: On bay front. Electric lights.

Whitefish Point, Mich.—Mrs. Annie M. Carlson.

Steel tower: On light-house reservation, 667 feet east-northeast from tower, 31 feet north-northeast from fog warning No. 1.

LAKE MICHIGAN.

Beaver Island (St. James), Mich.—James McCann.

Steel tower: Church Hill.

Big Point Sable, Mich.—Mrs. Mary Lysaght.

Steel tower: On Life-Saving Service reservation, about $8\frac{1}{2}$ miles from Ludington Harbor.

Charlevoix, Mich.—Miss Florence M. Smith.

Steel tower: On bluff, south side of harbor entrance.

Chicago, Ill.—Prof. Henry J. Cox, Weather Bureau, Federal Building.

Steel tower: On South Breakwater, near life-saving station, Chicago Harbor, Ill.

Steel tower: On southwest corner of Life-Saving Service reservation, South Chicago. Electric lights.

Church Hill, Beaver Island, Mich.—Norbert Wilhelm.

Steel tower: On Church Hill, about $1\frac{1}{2}$ miles south of St. James, Beaver Island. Oil lights.

Escanaba, Mich.—H. S. Cole, observer.

Steel tower: On roof of office building, 813 Ludington street. Electric lights.

Frankfort, Mich.—Miss Amelia Morency.

Steel tower: Life-saving station. Electric lights.

Gladstone, Mich.—Paul B. Hammond.

Flagstaff: Top of elevator at docks, "Soo Ry." Electric lights.

Glen Haven, Mich.—Eva E. Day.

Steel tower: West end of Day's pier.

Grand Haven, Mich.—C. H. Eshleman, observer.

Steel tower: Cutler House, corner Third and Washington streets. Electric lights.

Green Bay, Wis.—F. W. Conrad, observer.

Steel tower: On roof of Weather Bureau office, Parmentier Block, 324 to 328 Washington street. Electric lights.

Harbor Springs, Mich.—V. A. Pool.

Steel tower: Foot of Spring street, on the bluff.

Holland, Mich.—Mrs. Madalen A. Van Putten.

Flagstaff: Life-saving station, Macatawa Beach.

Kenosha, Wis.—J. C. McNally.

Steel tower: Near steamboat landing. Electric lights.

Kewaunee, Wis.—John Dishmaker.

Flagstaff: Near harbor, close to telegraph office.

Ludington, Mich.—J. O. Ellison.

Steel tower: Near Life-Saving Service station. Electric lights.

Macatawa, Mich.—Mrs. Jennie Van Weelden.

Flagstaff: In front of life-saving station.

Mackinaw, Mich.—Chas. T. Dagwell.

Steel tower: On grounds of the Lake Marine News Association. Electric lights.

Manistee, Mich.—F. V. Davis.

Steel tower: Corner Pine and Second streets. Electric lights. Life-saving station, north side of entrance to harbor. Tower on west side of reservation. Oil lights.

Manitowoc, Wis.—T. C. Torrison.

Steel tower: On river front, two blocks from lake. Electric lights.

Menominee, Mich.—L. C. Collins.

Flagstaff: No. 1 engine house. Electric lights.

Michigan City, Ind.—Josephine R. Robb.

Steel tower: At north end of Franklin Street Bridge. Electric lights.

Milwaukee, Wis.—Henry B. Hersey, Inspector, Weather Bureau.

Flagstaff: United States Post-office Building. Electric lights.
Milwaukee, Wis., life-saving station.—Mrs. Mary E. Olsen.
Steel tower: Near life-saving station building. Electric lights.
Muskegon, Mich.—W. J. Miles.
Steel tower: On grounds of Pere Marquette Railway Company. Electric lights.
North Manitou Island, Mich.—Emma Smith.
Steel tower: On north-central part of Life-Saving Service reservation, North Manitou Island. Oil lights.
Pentwater, Mich.—Ida M. Ewald.
Steel tower: On southeast corner of Life-Saving Service reservation, Pentwater. Oil lights.
Racine, Wis.—J. C. Dorchester.
Steel tower: One block from lake on elevated ground. Electric lights.
St. Joseph, Mich.—Alberta E. Thomas.
Steel tower: On bluff near Hotel Whitcomb, in Lake Front Park. Electric lights.
Saugatuck, Mich.—Frank H. Wade.
Flagstaff: Post-office Building.
Sheboygan, Wis.—A. Leberman.
Steel tower: Post-office block. Electric lights.
South Haven, Mich.—Mrs. Anna Donahue.
Steel tower: On light-house reservation. Electric lights.
South Manitou Island.—Clara J. Pugh.
Steel tower: Near Weather Bureau cable station. Electrical connection with mainland.
Sturgeon Bay, Wis.—E. W. Long.
Steel tower: East side entrance to canal. Electric lights.

LAKE HURON.

ALPENA, MICH.—Frank Jermin, assistant observer.
Steel tower: Chisholm street near First. Electric light.
Presque Isle Light.—Miss Kate L. Garrity.
Steel tower: Near light-house.
Bay City, Mich.—H. W. Perkins.
Flagstaff: On roof of Union Block, 716 North Water street.
Cheboygan, Mich.—R. E. Matt.
Steel tower: Near the steamboat dock. Electric lights.
Detour, Mich.—John F. Goetz.
Steel tower: On Dawson street, about 500 feet from telegraph office.
East Tawas, Mich.—John W. Tait.
Posts warnings only.
Mackinac Island, Mich.—Helen M. Donnelly.
Steel tower: On Biddles Point.
Middle Island, Mich.—Elizabeth A. Motley.
Steel tower: About 400 feet from station.
Oscoda, Mich.—William McFarlane.
Steel tower: Ninety feet from shore line, 15 feet from dock driveway.
Ottawa Point, Mich.—Rebecca M. Small.
Steel tower: Life-saving station, repeating displays from East Tawas.
Pointe aux Barques, Mich.—Carrie M. Frahm.
Steel tower: Extreme north part of Life-Saving Service reservation. Oil light.
PORT HURON, MICH.—Edward A. Brown, observer.
Flagstaffs: United States Custom-House. Electric lights. Kendall Marine Company, foot of Sarnia street. Two 16-candlepower lights, one red and one white, displayed from veranda of reporting station, 30 feet above river.
Steel tower: Millers coal dock. Electric lights.
Lakeview Beach life-saving station.—Mrs. E. J. Plough.
Flagstaff: Life-saving station.
Harbor Beach, Mich.—E. C. Reinelt.
Steel tower: High ground near F. and P. M. Railway depot.
Thunder Bay Island, Mich.—Celia E. Persons.
Steel tower: Southeast side of island near watchhouse.

LAKE ST. CLAIR.

DETROIT, MICH.—Norman B. Conger, inspector and marine agent.
Steel tower: On roof of Majestic Building.
Flagstaffs: On United States mail boat. Smith's coal dock. Electric lights.

LAKE ERIE.

Ashtabula, Ohio.—C. M. Foust.
Steel tower: At east end of drawbridge. Electric lights. The steel tower is used for flag warnings only. The electric lights are displayed from a special support on the roof of Marine Block.
BUFFALO, N. Y.—D. Cuthbertson, local forecaster.
Steel tower: For electric lights.
Flagstaff: For flag displays. Both on Prudential Building, Church and Pearl streets.
Frog Island, near Buffalo, N. Y.—J. Snyder.
Flagstaff: Near southern end of Frog Island, N. Y. Oil lights.
Buffalo life-saving station.—Julia A. Griesser.
Steel tower: Southeast corner of Life-Saving Service reservation on south side of south pier at entrance to Buffalo Harbor. Electric lights.
CLEVELAND, OHIO.—James Kenealy, local forecaster.
Steel tower: On west Government pier.
Flagstaffs: Society for Savings Building. Life-saving station, Mrs. Hannah K. Hensen.
Conneaut Harbor, Ohio.—W. B. Risley.
Steel tower: On highest bluff at harbor. Electric lights.
Dunkirk, N. Y.—D. F. Ganey.
Steel tower: Foot of Eagle street on triangle between Eagle street dock and Scully Lumber Company dock.
ERIE, PA.—G. R. Oberholzer, local forecaster.
Steel tower: At Soldiers' Home grounds.
Flagstaffs: Federal Building. Soft-coal docks. Electric lights.
Fairport Harbor, Ohio.—Melvin L. Root.
Steel tower: On bluff 600 feet from Grand River. Electric lights.
Huron, Ohio.—Jabez Wright.
Steel tower: At foot of Main street, between lake shore and river bank. Electric lights.
Kelleys Island, Ohio.—F. J. Reinheimer.
Steel tower: On hill near steamboat wharf, in front of post-office.
Lorain, Ohio.—T. H. Tristram.
Steel tower: West end of drawbridge between River and Broadway streets. Electric lights.
Marblehead, Ohio, life-saving station.—Mrs. Martha M. Griesser.
Steel tower: On grounds of the Kelleys Island Line and Transport Company.
Flagstaff: Eighty feet east of life-saving station.
Put-in Bay, Ohio.—Henry Fox.
Steel tower: Fox & Son's dock.
SANDUSKY, OHIO,—E. H. Nimmo, observer.
Flagstaff: Post-office Building, corner of Columbus avenue and Market street. Electric lights.
Stony Point, N. Y. (West Seneca, N. Y.).—Capt. T. C. Jacobsen.
Steel tower: Three hundred feet north of the southern end of the Government break wall. Electric lights.
TOLEDO, OHIO.—W. S. Currier, local forecaster.
Flagstaff: Nicholas Building, northwest corner of Madison and Huron streets. Electric lights.
Tonawanda, N. Y.—James O'Connor.
Steel tower: State grounds.

LAKE ONTARIO.

Cape Vincent, N. Y.—V. M. Rice.
Steel tower: On United States Fish Commission wharf.
Charlotte, N. Y.—Addie F. Fobes.

Steel tower: Life-saving station.

Fort Niagara, N. Y., life-saving station.—Mrs. Annie Clemons.

Steel tower: Twenty-seven feet west of life-saving station, east side of entrance to Niagara River.

North Fair Haven, N. Y.—A. M. Eldridge.

Steel tower: Near custom-house.

Ogdensburg, N. Y.—E. J. Dinneen.

Steel tower: Center of Caroline street, about 200 feet from North Water street.

Oswego, N. Y.—J. G. Linsley, observer.

Flagstaffs: Weather Bureau office, custom-house, West Oneida street, between West First and Second streets. Oswego Yacht Club.

Fort Ontario life-saving station.—Emma L. Anderson.

Steel tower: One hundred and twenty-five feet southeast of life-saving station. Electric lights.

Sacketts Harbor, N. Y.—Clark M. Stearne.

Steel tower: On high bluff at end of Main street.

Sodus Point, N. Y.—M. M. Farrell.

Steel tower: Northern Central Railroad Company's grounds.

CANADIAN GREAT LAKES STORM-WARNING STATIONS.[2]

LIST OF PLACES ON THE GREAT LAKES AT WHICH STORM WARNINGS ARE DISPLAYED BY THE METEOROLOGICAL SERVICE OF THE DOMINION OF CANADA, R. F. STUPART, TORONTO, ONTARIO, DIRECTOR.

Fort William.—Signal mast adjoins Fort William Rowing Club.

Port Arthur.—Signal mast on the town end of the Government wharf.

Sault Sainte Marie.—Signal mast on Government wharf.

Tobermory.—Signal mast on the point between the two harbors.

Depot Harbor.—On Rocky Light Point, a little to the east of elevators.

Parry Sound.—Signal mast on a high ridge of land overlooking harbor.

Midland.—Signal mast on ridge in east, adjoining the town.

Collingwood.—Signal mast in line with piers and west of railway tracks.

Owen Sound.—Signal mast on the west side of harbor opposite Canadian Pacific Railway station.

Sarnia.—Signal mast on the wharf adjoining waterworks property.

Kinkardine.—Signal adjoining east wharf.

Goderich.—Signal mast on bluff near light-house.

Saugeen.—Signal mast at the corner of High and Lake streets.

Bayfield.—Signal mast overlooking harbor.

Pelee Island.—Signal mast near the light-house on the north point.

Port Stanley.—Warnings sent out and posted, but no signal displayed.

Port Dover.—Signal mast on wharf opposite Grand Trunk Railway station.

Port Colborne.—Signal mast on the canal bank.

Port Burwell.—Signal mast on hill overlooking harbor.

Amherstburg.—Signal mast on the wharf near waterworks wharf.

Port Dalhousie.—Signal mast on the canal bank.

Burlington.—Signal mast at the light-house near the swing bridge.

Oakville.—Signal mast on the bluff just above the wharf.

Port Credit.—On the lake shore.

Toronto.—Signal masts at Queen's wharf and also adjoining fog-signal house at Eastern gap.

Port Hope.—Signal mast on the wharf.

Coburg.—Signal mast on the town end of wharf.

Deseronto.—Signal mast at the end of railway wharf.

Prinyer.—Signal mast inside Prinyer Cove.

Kingston.—Signal mast on the water front a little west of steamboat wharf.

[2] This list has not been revised.

Wind-Barometer Table for the Great Lakes.

Height of barometer (lake level).	Direction of wind.	Character of the weather and wind indicated.
29.40 to 29.60, and steady	West	Fair, slight change in the temperature, gentle to fresh winds.
29.40 to 29.60, rising	do	Fair, cooler, fresh west to northwest winds.
29.40 to 29.60, falling	South	Warmer, increasing northerly winds.
29.60, or above, falling rapidly	East to south	Warmer, rain or snow within 36 hours, increasing east to southeast winds.
29.60, or above, rising rapidly	West to north	Cool and clear, quickly followed by warmer, variable winds.
29.60, or above, steady	Variable	No immediate change, but winds will go to south inside of 36 hours.
29.40, or below, falling slowly	South to east	Rain or snow, increasing easterly winds.
29.40, or below, falling rapidly	do	Rain or snow, high easterly winds, followed within 48 hours by clearing, cooler, west to northwest winds.
29.40, or below, rising slowly	South to west	Clearing, colder, fresh to brisk west to northwest winds.
29.20, or below, falling rapidly	South to east	Severe storm of wind and rain, and wind shifting to northwest within 36 hours.
29.20, or below, falling rapidly	East to north	Severe northeaster, with heavy rain or snow, and winds backing to northwest.
29.20, or below, rising rapidly	Going west	Clearing and cooler, probably cold wave in winter.

ICE ON THE GREAT LAKES.

The following table has been compiled from as many stations as reliable data could be obtained from. Some of the stations furnished data for some years that it was found necessary to discard as unreliable. The complete data from the Straits of Mackinac have not been obtainable, and I have furnished all that I have been able to obtain. Some Cleveland data was obtained from the custom-house records, but it has been discarded for the record kept by the Detroit and Cleveland Steam Navigation Company, which covers a much longer period.

Dates of opening and closing of navigation at the more important ports on Lake Michigan.

Year.	Duluth.		Two Harbors.		Ashland.		Ontonagon.		Eagle Harbor.		Year.
	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	
1871	May 4	Dec. 6									1871
1872	May 14	Nov. 24									1872
1873	May 24	Nov. 25							May 1		1873
1874	May 4	Dec. 9							May 1		1874
1875	May 15	Dec. 2							May 20	Dec. 3	1875
1876	May 9	Dec. 4							May 13	Dec. 4	1876
1877	Apr. 29	Dec. 7							Apr. 23	Dec. 3	1877
1878	Apr. 12	Nov. 14							Mar. 30		1878
1879	Apr. 28	Nov. 29							Apr. 21		1879
1880	May 1	Nov. 30							Apr. 22		1880
1881	May 9	Dec. 27							May 5	Dec. 3	1881
1882	Apr. 23	Dec. 4							Apr. 24		1882
1883	May 2	Dec. 4	May 9	Dec. 29			Apr. 15	Dec. 3	May 1		1883
1884	May 1	Dec. 1	Apr. 23	Nov. 8			May 1	Nov. 30	May 5		1884
1885	Apr. 27	Nov. 29	May 22	Nov. 16			Apr. 22	Nov. 30	May 4		1885

Dates of opening and closing of navigation at the more important ports on Lake Michigan—Continued.

Year.	Duluth.		Two Harbors.		Ashland.		Ontonagon.		Eagle Harbor.		Year.
	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	
1886	May 4	Nov. 30	May 8	Nov. 12			Apr. 15	Dec. 1	Apr. 23	Nov. 30	1886
1887	May 6	Nov. 26	May 2	Nov. 24			May 1	Dec. 1	May 4	Nov. 30	1887
1888	May 12	Dec. 2	Apr. 21	Jan. 24, 1889			Apr. 25	Dec. 4	May 4		1888
1889	Apr. 20	Dec. 4	May 1	Nov. 28			Apr. 15	Dec. 5	Apr. 11		1889
1890	Apr. 23	Dec. 4	Apr. 20	Dec. 5			Apr. 17	Dec. 2	Apr. 19	Dec. 1	1890
1891	Apr. 30	Dec. 7	May 1	Dec. 5			Apr. 18	Nov. 30	Apr. 13	Dec. 5	1891
1892	Apr. 22	Dec. 5	Apr. 22	Dec. 6			Apr. 9	Dec. 3	Apr. 11	Dec. 7	1892
1893	May 9	Dec. 8	May 9	Nov. 24			Apr. 22	Dec. 1	Apr. 27	Dec. 7	1893
1894	Apr. 19	Dec. 7	Apr. 21	Nov. 28	May 6	Nov. 29	Apr. 16	Dec. 1	Apr. 16	Dec. 8	1894
1895	Apr. 30	Dec. 10	May 1	Dec. 2	Apr. 16	Nov. 29	Apr. 14	Dec. 4	Apr. 22	Dec. 12	1895
1896	Apr. 23	Dec. 11	Apr. 24	Nov. 29	Apr. 26	Nov. 27	Apr. 14	Dec. 8	Apr. 18	Dec. 10	1896
1897	Apr. 23	Dec. 13	Apr. 24	Dec. 16	Apr. 27	Nov. 26	Apr. 7	Nov. 30	Dec. 17	Dec. 16	1897
1898	Apr. 16	Dec. 15	Mar. 25	Dec. 7	Apr. 18	Nov. 30	Mar. 24	Dec. 5	Dec. 7	Dec. 15	1898
1899	May 2	Dec. 15	May 3	Dec. 17	May 1	Dec. 11	Apr. 16	Dec. 12	Dec. 30	Dec 19	1899
1900	Apr. 24	Dec. 5	Apr. 22	Dec. 14	Apr. 20	Dec. 1	Apr. 8	Dec. 12	Dec. 17	Dec. 13	1900
1901	May 2	Dec. 7	May 6	Dec. 2	Apr. 27	Dec. 6	Mar. 29	Dec. 10	Dec. 21	Dec. 12	1901
1902	Apr. 6	Dec. 8	Apr. 2	Dec. 7	Apr. 6	Dec. 8	Apr. 8	Dec. 11	Dec. 1	Dec. 17	1902
1903	Apr. 11	Dec. 9	Apr. 10	Dec. 4	Apr. 18	Dec. 4	Apr. 26	Dec. 6	Dec. 10	Dec. 12	1903
1904	May 12	Dec. 14	June 6 [d]	Dec. 6	May 11	Dec. 7	Apr. 9	Dec. 15	May 7	Dec. 15	1904
1905	Apr. 20	Dec. 15	Apr. 8	Dec. 7	Apr. 18	Dec. 11	Apr. 5	Dec. 9	Apr. 8	Dec. 18	1905
1906	Apr. 15	Dec. 14	Apr. 4	Dec. 8	Apr. 17	Dec. 12	Apr. 20	Dec. 12	Apr. 14	Dec. 19	1906
1907	Apr. 26	Dec. 12	Apr. 16	Dec. 2	Apr. 23	Dec. 4	Apr. 20	Dec. 11	Apr. 22	Dec. 16	1907
1908	Apr. 29						Apr. 20		Apr. 18		1908

Year.	Houghton.		Marquette.		Grand Marais.		Whitefish.		Soo.		Year.
	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	
1855										Nov. 23	1855
1856									May 4	Nov. 28	1856
1857									May 9	Nov. 30	1857
1858									Apr. 18	Nov. 20	1858
1859									May 3	Nov. 28	1859
1860		?							May 11	Nov. 26	1860
1861									May 3	Nov. 14	1861
1862									Apr. 27	Nov. 27	1862
1863									Apr. 28	Nov. 24	1863
1864			May 8						May 2	Dec. 4	1864
1865			Apr. 28						May 1	Dec. 3	1865
1866			May 9						May 5	Dec. 3	1866
1867			May 6						May 4	Dec. 3	1867
1868			May 3						May 2	Dec. 3	1868
1869			May 7						May 4	Nov. 29	1869
1870			Apr. 30						Apr. 29	Dec. 1	1870
1871			May 9	Nov. 22					May 8	Nov. 29	1871
1872			May 13	Nov. 25					May 11	Nov. 26	1872
1873			May 21	Nov. 22			May 7	Nov. 22	May 5	Nov. 18	1873
1874			May 13	Nov. 27			May 12	Nov. 22	May 12	Dec. 2	1874
1875			May 20	Nov. 24			May 9	Dec. 1	May 12	Dec. 2	1875
1876			May 12	Nov. 26			May 9	Nov. 28	May 8	Nov. 26	1876
1877			May 5	Nov. 28			May 4	Nov. 29	May 2	Nov. 30	1877
1878			Apr. 18	Nov. 26			Apr. 9	Nov. 29	Apr. 8	Dec. 3	1878
1879			May 8	Nov. 23			May 4	Dec. 1	May 2	Dec. 3	1879
1880			May 4	Nov. 29			Apr. 27	Nov. 14	Apr. 28	Nov. 15	1880
1881			May 11	Nov. 23				Nov. 29	May 7	Dec. 5	1881
1882			Apr. 25	Nov. 27	Apr. 23	Nov. 30	Apr. 22	Dec. 6	Apr. 21	Dec. 3	1882
1883			May 5	Nov. 28	Apr. 27	Nov. 30		Dec. 10	May 2	Dec. 11	1883
1884			Apr. 30	Dec. 5	Apr. 27	Nov. 30	Apr. 30	May 11	Apr. 23	Dec. 10	1884
1885			May 11	Dec. 2	May 10	Nov. 30	May 11	Dec. 7	May 6	Dec. 2	1885
1886			Apr. 28	Dec. 1	Apr. 27	Nov. 30	Apr. 27	Dec. 7	Apr. 25	Dec. 4	1886
1887			May 5	Dec. 1	May 3	Nov. 30	May 3	Dec. 6	May 1	Dec. 2	1887
1888			May 11	Nov. 26	May 10	Nov. 30	May 9	Dec. 3	May 7	Dec. 3	1888
1889			Apr. 21	Nov. 30	Apr. 17	Dec. 4	Apr. 16	Dec. 10	Apr. 15	Dec. 4	1889
1890			Apr. 23	Dec. 3	Apr. 21	Dec. 4	Apr. 22	Dec. 8	Apr. 20	Dec. 3	1890
1891		Nov. 30	May 1	Dec. 2	May 1	Dec. 5	Apr. 28	Dec. 10	Apr. 27	Dec. 8	1891
1892	Apr. 26	Nov. 30	Apr. 21	Dec. 6	Apr. 23	Nov. 30	Apr. 20	Dec. 9	Apr. 18	Dec. 6	1892
1893	May 9	Nov. 29	May 7	Dec. 3	May 6	Dec. 5	May 1	Dec. 6	Apr. 29	Dec. 6	1893
1894	Apr. 22	Nov. 30	Apr. 20	Dec. 4	Apr. 16	Dec. 4	Apr. 18	Dec. 6	Apr. 17	Dec. 6	1894
1895	Apr. 25	Dec. 2	Apr. 30	Dec. 8	Apr. 28	Dec. 9	Apr. 28	Dec. 12	Apr. 23	Dec. 11	1895
1896	Apr. 24	Nov. 26	Apr. 22	Dec. 7	Apr. 21	Dec. 9	Apr. 21	Dec. 9	Apr. 18	Dec. 9	1896
1897	Apr. 23	Dec. 2	Apr. 20	Dec. 6	Apr. 21	Dec. 15	Apr. 21	Dec. 11	Apr. 21	Dec. 13	1897
1898	Apr. 17	Dec. 4	Apr. 16	Dec. 1	Apr. 14	Dec. 12	Apr. 11	Dec. 15	Apr. 13	Dec. 15	1898
1899	May 1	Dec. 15	May 2	Dec. 18	May 1	Dec. 12	Apr. 29	Dec. 22	Apr. 29	Dec. 19	1899
1900	Apr. 19	Dec. 8	Apr. 24	Nov. 30	Apr. 23	Dec. 6	Apr. 22	Dec. 12	Apr. 22	Dec. 12	1900
1901	Apr. 23	Dec. 8	Apr. 30	Nov. 30	May 1	Dec. 12	Apr. 25	Dec. 12	Apr. 27	Dec. 11	1901
1902	Apr. 4	Dec. 13	Apr. 8	Dec. 15	Apr. 7	Dec. 14	Mar. 30	Dec. 16	Apr. 4	Dec. 16	1902
1903	Apr. 15	Dec. 9	Apr. 18	Dec. 11	Apr. 10	Dec. 11	Apr. 8	Dec. 12	Apr. 9	Dec. 11	1903
1904	Apr. 20	Dec. 5	June 2 [d]	Dec. 6	May 8	Lec. 14	May 5	Dec. 26	May 5	Dec. 14	1904
1905	Apr. 12	Dec. 11	Apr. 20	Dec. 15	Apr. 20	Dec. 16	Apr. 9 [e]	Dec. 17	Apr. 14	Dec. 17	1905
1906	Apr. 18	Dec. 10	Apr. 17	Dec. 10	Apr. 17	Dec. 15	Apr. 15	Dec. 22	Apr. 15	Dec. 19	1906
1907	Apr. 29	Dec. 9	Apr. 27	Dec. 12	Apr. 26	Dec. 12	Apr. 23	Dec. 14	Apr. 23	Dec. 14	1907
1908	Apr. 22		Apr. 30		Apr. 26		Apr. 25		Apr. 24		1908

[d] Opening delayed on account of "Masters' and Pilots'" strike. [e] Boat stuck in ice—blockade opened on the 19th.

Dates of opening and closing of navigation at the more important ports on Lake Michigan—Continued.

Year.	Gladstone.		Escanaba.		Green Bay.		Sturgeon Bay.		Michigan City.		Year.
	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	
1867			Apr. 27	[a]							1867
1868			[a]	[a]							1868
1869			May 6	[a]							1869
1870			Apr. 17	[a]							1870
1871			Apr. 11	Nov. 26							1871
1872			Apr. 28	[a]							1872
1873			May 2	[a]							1873
1874			Apr. 30	[a]	Apr. 15	Nov. 28					1874
1875			Apr. 29	[a]	Apr. 28	Nov. 28					1875
1876			Apr. 26	Dec. 9	Apr. 17	Dec. 1					1876
1877			Apr. 21	[a]	Apr. 16	Jan. 23, 1878					1877
1878			Mar. 5	Dec. 29	Mar. 13	Dec. 11					1878
1879			Apr. 25	[a]	Apr. 15	Nov. 30					1879
1880			Apr. 3	Nov. 29 [b]	Apr. 1	Nov. 20					1880
1881			May 3	Dec. 5	May 6	Dec. 14					1881
1882			Apr. 7	Dec. 7	Apr. 1	Dec. 4					1882
1883			Apr. 23	Dec. 29	Apr. 16	Dec. 15					1883
1884			Apr. 19	Dec. 2	Apr. 24	Dec. 3					1884
1885			May 5	Dec. 1	Apr. 29	Dec. 6					1885
1886			Apr. 23	Dec. 25	Apr. 20	Dec. 26					1886
1887			Apr. 28	Dec. 6	Apr. 24	Dec. 27					1887
1888			May 2	Nov. 30	May 2	Dec. 12					1888
1889			Apr. 4	Dec. 6	Apr. 8	Dec. 7					1889
1890			Apr. 15	Dec. 5	Apr. 11	Dec. 4					1890
1891			Apr. 30	Dec. 3	Apr. 23	Nov. 30					1891
1892			Apr. 10	Dec. 3	Apr. 11	Dec. 1					1892
1893	Apr. 28	Dec. 17	Apr. 27	Dec. 14	Apr. 15	Dec. 3					1893
1894	Apr. 15	Dec. 7	Apr. 6	Dec. 6	Mar. 31	Dec. 10					1894
1895	Apr. 28	Dec. 7	Apr. 20	Dec. 3	Apr. 16	Dec. 2			Apr. 10	Dec. 9	1895
1896	Apr. 18	Dec. 23	Apr. 17	Dec. 3	Apr. 16	Dec. 6			Apr. 6	Dec. 24	1896
1897	Apr. 16	Dec. 26	Apr. 14	Dec. 23	Apr. 12	Dec. 11			Apr. 1	Dec. 14	1897
1898	Apr. 15	Dec. 19	Apr. 11	Dec. 14	Apr. 5	Dec. 7	Apr. 12	Dec. 25	Mar. 14	Dec. 16	1898
1899	Apr. 22	Jan. 1, 1900	Apr. 23	Dec. 25	Apr. 26	Dec. 12	Apr. 20	Feb. 21, 1900	Apr. 4	Dec. 18	1899
1900	Apr. 21	Jan. 3, 1901	Apr. 18	Dec. 23	Apr. 18	Dec. 8	Apr. 20	Dec. 22	Apr. 12	Dec. 14	1900
1901	Apr. 18	Dec. 17	Apr. 18	Dec. 19	Apr. 26	Dec. 5	Apr. 17	Dec. 18	Apr. 2	Dec. 11	1901
1902	Apr. 11	Dec. 14	Mar. 31	Dec. 22	Apr. 3	Dec. 8	Mar. 29	Dec. 27	Apr. 2	Dec. 13	1902
1903	Apr. 10	Dec. 6	Mar. 29	Dec. 8	Mar. 31	Dec. 9	Apr. 10	Dec. 13	Mar. 17	Dec. 14	1903
1904	Apr. 25	Dec. 7	Apr. 28	Dec. 18	May 4	Dec. 7	Apr. 28	Dec. 14	Apr. 19	Dec. 12	1904
1905	Apr. 19	Dec. 11	Apr. 18	Dec. 23	Apr. 19	Dec. 5	Apr. 12	Dec. 21	Apr. 5	Dec. 20	1905
1906	Apr. 21	Dec. 12	Apr. 15	Dec. 17	Apr. 14	Dec. 6	Apr. 11	Jan. 5, 1907	Apr. 5	Dec. 21	1906
1907	Apr. 20	Dec. 5	Apr. 10	Dec. 11	Apr. 7	Dec. 4	Mar. 30	Dec. 27	Mar. 27	Dec. 16	1907
1908	Apr. 25		Apr. 19		Apr. 14		Mar. 14		Apr. 4		1908

Year.	Saint Joseph.		South Haven.		Saugatuck.		Muskegon.		Harbor Springs.		Year.
	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	
1873				Jan. 14, 1874							1873
1874				Jan. 1, 1875							1874
1875			Apr. 12								1875
1876			Mar. 27	Dec. 10							1876
1877			Mar. 8	Dec. 28							1877
1878			Mar. 7	Dec. 20							1878
1879			Mar. 6	Dec. 23							1879
1880			Mar. 1	Dec. 6							1880
1881			Mar. 21	Jan. 18, 1882							1881
1882			Feb. 26	Dec. 15							1882
1883			Apr. 4	Dec. 25							1883
1884			Mar. 22	Dec. 18						Dec. 12	1884
1885			Apr. 16	Dec. 15					May 3	Dec. 15	1885
1886			Mar. 19	Dec. 21	Mar. 18	Dec. 5			Apr. 21	Dec. 14	1886
1887			Mar. 8	Jan. 1, 1888	Mar. 22	Nov. 28			Apr. 29	Dec. 12	1887
1888	Apr. 10	Nov. 21	Mar. 20	Jan. 1, 1889					Apr. 30	Dec. 12	1888
1889	Apr. 9	Nov. 24	Mar. 15	[c]	Apr. 2	Dec. 12			Apr. 12	Dec. 14	1889
1890	Apr. 10	Nov. 26	[c]	[c]	Apr. 10	Nov. 15	Apr. 4	Dec. 11	Apr. 9	Dec. 18	1890
1891	Mar. 29	Nov. 29	[c]	Jan. 9, 1892	Apr. 8	Nov. 23	Apr. 4	Dec. 12	Apr. 15	Dec. 22	1891
1892	Mar. 14	Nov. 26	Feb. 27	Dec. 22	Mar. 29	Dec. 2	Apr. 5	Dec. 19	Apr. 5	Dec. 17	1892
1893	Apr. 3	[c]	Mar. 13	Feb. 4, 1894	Apr. 10	Nov. 15	Apr. 12	Dec. 9	Apr. 14	Dec. 12	1893
1894	[c]	Jan. 21, 1895	Mar. 6	Jan. 1, 1895	Apr. 8	Oct. 30	Apr. 2	Feb. 28, 1895	Apr. 7	Dec. 17	1894
1895	Mar. 22	[c]	Mar. 24	Jan. 3, 1896	Apr. 1	Nov. 20	Apr. 1	Feb. 28, 1896	Apr. 16	Dec. 12	1895
1896	[c]	[c]	Mar. 11	Jan. 23, 1897	Apr. 5	Oct. 26	Mar. 4	Feb. 26, 1897	Apr. 14	Dec. 18	1896
1897	[c]	[c]	Mar. 7	Dec. 24, 1897	Apr. 20	Nov. 1	Mar. 1	Feb. 27, 1898	Apr. 10	Dec. 19	1897
1898	[c]	Dec. 17	Mar. 8	Dec. 15, 1898	Apr. 1	Oct. 26	Mar. 1	Feb. 26, 1899	Mar. 29	Dec. 15	1898
1899	Mar. 11	Jan. 1, 1900	Mar. 11	Dec. 27	Apr. 3	Oct. 21	Mar. 1	Feb. 23, 1900	Apr. 14	Dec. 24	1899
1900	Mar. 12	Jan. 1, 1901	Mar. 26	Jan. 16, 1901	Apr. 10	Oct. 25	Mar. 7	Dec. 17	Apr. 21	Dec. 14	1900
1901	Apr. 2	Dec. 28	Mar. 20	Dec. 19	Apr. 10	Oct. 30	Apr. 4	Dec. 13	Apr. 13	Dec. 17	1901
1902	Mar. 19	Dec. 16	Mar. 8	Dec. 31	Apr. 1	Oct. 15	Mar. 18	Dec. 17	Mar. 25	Dec. 14	1902
1903	Mar. 17	Dec. 9	Mar. 7	Dec. 15	Apr. 11	Oct. 18	Mar. 11	Dec. 18	Mar. 25	Dec. 13	1903
1904	Mar. 28	Dec. 22	Mar. 21	Dec. 23	Apr. 8	Oct. 20	Apr. 8	Jan. 2, 1905	Apr. 27	Dec. 11	1904
1905	Mar. 15	Dec. 17	Mar. 19	Feb. 4, 1906	Apr. 11	Oct. 24	Mar. 22	Feb. 28, 1906	Apr. 21	Dec. 19	1905
1906	Feb. 28	Dec. 25		Jan. 20, 1907	Apr. 9	Nov. 7	Mar. 2	Jan. 24, 1907	Apr. 9	Dec. 19	1906
1907	Mar. 10	Dec. 20	Mar. 12	Dec. 31, 1907	Apr. 7	Oct. 30	Mar. 17	Feb. 12, 1908	Apr. 5	Dec. 13	1907
1908			Mar. 10		Apr. 18		Mar. 23		Apr. 18		1908

[a] Date of opening or closing questioned. [b] 21 vessels frozen in. [c] Open all winter.

Dates of opening and closing of navigation at the more important ports on Lakes Huron and Erie.

Year.	Straits of Mackinac.		Detour.		Cheboygan.		Alpena.		Oscoda.		Year.
	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	
1854	Apr. 25										1854
1855	May 1										1855
1856	May 2										1856
1857	May 1										1857
1858	Apr. 5										1858
1859	Apr. 3										1859
1860	Apr. 13										1860
1861	Apr. 25										1861
1862	Apr. 18										1862
1863	Apr. 17										1863
1864	Apr 28										1864
1865	Apr. 21										1865
1866	Apr. 28										1866
1867	Apr. 23										1867
1868	Apr. 19										1868
1869	Apr. 28										1869
1870	Apr. 18										1870
1871	Apr. 2										1871
1872	Apr. 28										1872
1873	May 1						Apr. 3				1873
1874	Apr. 29						[a]	[a]			1874
1875	Apr. 28						Apr. 19	Dec. 14			1875
1876	Apr. 28						Apr. 19	Dec. 8			1876
1877	Apr. 18						Apr. 20	[a]			1877
1878	Mar. 15						Mar. 10	[a]			1878
1879	Apr. 22						Apr. 5	Dec. 10			1879
1880	Apr. 4						Mar. 6	Dec. 12			1880
1881	May 3						Apr. 22	Dec. 12			1881
1882	Apr. 3						Mar. 6	Dec. 9			1882
1883	Apr. 28						Apr. 16	Dec. 19			1883
1884	Apr. 25						Apr. 11	Dec. 17			1884
1885	May 5						Apr. 26	Dec. 6			1885
1886	Apr. 21						Mar. 28 [b]	Dec. 16			1886
1887	Apr. 24						Apr. 18	Dec. 11			1887
1888	May 4						Apr. 29	Dec. 20			1888
1889	Apr. 6						Mar. 27 [b]	Dec. 2 [c]			1889
1890	Apr. 8						Feb. 28	Nov. 29			1890
1891	Apr. 17						Apr. 19	Dec. 24			1891
1892	Apr. 9						Apr. 6	Dec. 9			1892
1893	Apr. 17						Apr. 10	Dec. 8			1893
1894	Mar. 29						Mar. 13	Dec. 4 [c]			1894
1895	Apr. 1	[d]					Apr. 11	Dec. 6			1895
1896	Apr. 16	Dec. 14					Apr. 9	Dec. 5 [c]			1896
1897	Apr. 7	Dec. 14					Mar. 25	Dec. 13 [c]			1897
1898	Mar. 28	Dec. 13					Mar. 24	Dec. 12 [c]	Apr. 1	Dec. 7	1898
1899	Apr. 26	Dec. 9					Apr. 21	Dec. 17 [c]	Apr. 22	Dec. 30	1899
1900	Apr. 18	Dec. 11 [e]	May 3	Dec. 2			Apr. 13	Dec. 16	Apr. 20	Dec. 13	1900
1901	Apr. 14	Dec. 14 [f]	Apr. 20	Dec. 14	Apr. 1	Dec. 24	Apr. 16	Dec. 15	May 1	Dec. 5	1901
1902	Apr. 2	Dec. 12 [g]	Mar. 30	Dec. 17	Mar. 26	Dec. 24	Mar. 21	Dec. 18	Apr. 4	Dec. 10	1902
1903	Mar. 23	Dec. 10 [h]	Apr. 19	Dec. 15	Apr. 1	Dec. 12	Mar. 9	Dec. 21	Apr. 7	Dec. 4	1903
1904	Apr. 29	Jan. 10, 1905	Apr. 15	Dec. 24	Apr. 26	Dec. 22	Apr. 24	Dec. 16	May 12	Nov. 30	1904
1905	Apr. 18	Dec. 14	Apr. 4	Dec. 16	Apr. 22	Dec. 22	Apr. 6	Dec. 28	Apr. 10	Dec. 4	1905
1906	Apr. 10	Jan. 24, 1907	Apr. 10	Dec. 18	Apr. 16	Dec. 22	Apr. 7	Dec. 15	Apr. 10	Dec. 1	1906
1907	Apr. 1	Dec. 14	Apr. 3	Dec. 19	Apr. 29	Dec. 23	Mar. 29	Dec. 13	Apr. 16	Dec. 2	1907
1908	Apr. 19		Apr. 18		Apr. 19		Apr. 10		Apr. 14		1908

[a] Date of opening or closing questioned. [b] First boat entered on records of U. S. Customs Service. [c] Last boat entered on records of U. S. Customs Service. [d] Dates of closing of lights. [e] Last passage steamer *Geo. Gray*, with coal for Milwaukee, December 18. [f] Last passage steamer *Christopher*, December 22. [g] Last passage steamer *Jas. Watts*, December 20, 1901. [h] Last passage P. M. steamers numbers 16 and 20 on December 24, 1903.

Year.	Bay City.		Port Huron.		Detroit.		Toledo.		Put-in-Bay.		Year.
	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	
1863					Mar. 28						1863
1864					Mar. 28						1864
1865					Mar. 28						1865
1866					Apr. 10						1866
1867					Apr. 8						1867
1868					Mar. 24						1868
1869					Apr. 6						1869
1870					Apr. 8						1870
1871					Mar. 21		Mar. 16	Dec. 4			1871
1872					Apr. 8		Apr. 9	Nov. 29			1872
1873					Apr. 10		Mar. 28	Dec. 5			1873
1874				Dec. 9	Mar. 21	Dec. 18	Mar. 19	Dec. 9			1874
1875			Apr. 10	Dec. 11	Apr. 12	Dec. 18	Apr. 13	Dec. 10			1875
1876			Apr. 9	Dec. 16	Apr. 4	Dec. 10	Apr. 3	Dec. 5			1876
1877			May 3	Dec. 10	Apr. 10	Dec. 18	Apr. 17	Dec. 10			1877
1878			Mar. 24	Dec. 15	Mar. 21	Dec. 15	Mar. 18	Dec. 18			1878
1879			Mar. 20	Dec. 14	Apr. 1	Dec. 25	Apr. 7	Dec. 15			1879
1880			Mar. 22	Dec. 10	Mar. 8	Dec. 15	Mar. 3	Dec. 5			1880
1881			May 3	Jan. 3, 1882	Apr. 19	Dec. 7	Apr. 7	Dec. 27			1881
1882			Mar. 7	Dec. 10	Mar. 14	Dec. 9	Feb. 25	Dec. 9			1882
1883			Apr. 17	Dec. 24	Apr. 7	Dec. 10	Apr. 9	Dec. 18			1883
1884			Apr. 9	Dec. 17	Apr. 2	Dec. 10	Mar. 30	Dec. 15			1884
1885			Apr. 23	Dec. 13	Apr. 17	Dec. 8	Apr. 13	Dec. 26			1885
1886			Mar. 27	Dec. 12	Mar. 25	Dec. 15	Mar. 23	Dec. 1			1886
1887			Apr. 12	Dec. 10	Mar. 8	Dec. 13	Apr. 4	Dec. 11			1887

Dates of opening and closing of navigation at the more important ports on Lakes Huron and Erie—Continued.

Year.	Bay City.		Port Huron.		Detroit.		Toledo.		Put-in-Bay.		Year.
	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	
1888			Apr. 7	Dec. 11	Mar. 28	Dec. 7	Apr. 7	Dec. 3			1888
1889			Apr. 1	Dec. 11	Mar. 21	Dec. 10	Apr. 10	Dec. 3			1889
1890			Mar. 23	Dec. 25	Mar. 1	Dec. 12	Mar. 24	Dec. 11			1890
1891			Apr. 19	Dec. 22	Mar. 13	Dec. 10	Apr. 5	Dec. 9		Jan. 13, 1892	1891
1892			Apr. 6	Dec. 15	Mar. 27	Dec. 18	Mar. 24	Dec. 9	Feb. 10	Jan. 4, 1893	1892
1893			Apr. 3	Dec. 13	Mar. 29	Dec. 12	Mar. 21	Dec. 7	Mar. 9	Jan 28, 1894	1893
1894			Mar. 11	Dec. 19	Mar. 19	Dec. 20	Mar. 22	Dec. 27	Feb. 21	Jan. 6, 1895	1894
1895	Apr. 1	Dec. 2	Apr. 7	Dec. 28	Apr. 4	Dec. 20	Apr. 13	Dec. 28	Mar. 6	Jan. 9, 1896	1895
1896	Mar. 31	Dec. 8	Apr. 8	Dec. 21	Mar. 30	Dec. 23	Apr. 4	Dec. 26	Feb. 5	Jan. 11, 1897	1896
1897	Apr. 5	Dec. 10	Mar. 27	Dec. 25	Mar. 13	Dec. 24 [b]	Mar. 22	Dec. 23	Mar. 7	Jan. 31, 1898	1897
1898	Mar. 15	Dec. 7	Mar. 23	Dec. 23	Mar. 28	Dec. 18	Mar. 17	Dec. 9	Mar. 7	Jan. 3, 1899	1898
1899	Apr. 7	Dec. 25	Apr. 18	Dec. 28	Mar. 27	Dec. 26	Apr. 12	Dec. 22	Mar. 8	Jan. 7, 1900	1899
1900	Apr. 7	Dec. 3	Apr. 17	Dec. 18	Apr. 9	Dec. 19	Apr. 4	Dec. 22	Mar. 25	Jan. 6, 1901	1900
1901	Apr. 10	Dec. 15	May 8	Dec. 19	Apr. 1	Dec. 18	Mar. 25	Dec. 15	Mar. 15	Jan. 2, 1902	1901
1902	Mar. 18	Dec. 13	Mar. 22	Dec. 22	Mar. 18	Dec. 13 [c]	Mar. 19	Dec. 20	Mar. 6	Jan. 11, 1903	1902
1903	Mar. 23	Dec. 4	Mar. 25	Dec. 13	Mar. 18	Dec. 2 [d]	Mar. 30	Dec. 15	Mar. 3	Dec. 29	1903
1904	Mar. 30	Dec. 10	Apr. 28	Dec. 17	Apr. 5	Dec. 12	Apr. 15	Dec. 15	Mar. 5	Jan. 1, 1905	1904
1905	Mar. 28	Dec. 16	Apr. 1	Dec. 23	Apr. 3	Dec. 27	Apr. 8	Dec. 16	Mar. 11	Jan. 9, 1906	1905
1906	Mar. 28	Dec. 13	Apr. 3	Dec. 18	Mar. 5	Dec. 11	Apr. 3	Dec. 14	Feb. 26	Jan. 8, 1907	1906
1907	Mar. 27	Dec. 10	Apr. 28	Dec. 16	Mar. 28	Dec. 6	Apr. 1	Dec. 23	Mar. 11	Jan. 5, 1908	1907
1908			Apr. 5		Apr. 1		Mar. 14		Mar. 9		1908

[b] Closing of navigation taken from Detroit and Cleveland line up to this date. After this date the date of last thru passage is given. The opening shown is date of first departure of Detroit and Cleveland line steamers. [c] Detroit and Cleveland line closed December 13. Steamer *Hopkins* past down for Toledo on December 23. [d] Steamer *John T. Hutchinson* past down on December 17.

Dates of opening and closing of navigation at the more important ports on Lakes Erie and Ontario.

Year.	Sandusky.		Huron.		Cleveland.		Erie.		Buffalo.		Year.
	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	
1815							Apr. 6	Jan. 5, 1816			1815
1816							Apr. 27	Dec. 16			1816
1817							Apr. 21	Dec. 12			1817
1818							Apr. 29	Dec. 7			1818
1819							Apr. 30	Dec. 5			1819
1820							May 11	Nov. 29			1820
1821							May 13	Dec. 7			1821
1822							Apr. 29	Dec. 4			1822
1823							May 4	Dec. 9			1823
1824							Apr. 22	Dec. 2			1824
1825							Mar. 17	Dec. 13			1825
1826							Apr. 2	Dec. 8			1826
1827											1827
1828											1828
1829							Jan. 29 [b]	Dec. 1			1829
1830							Apr. 5	Dec. 10			1830
1831							Mar. 29	Dec. 5			1831
1832							Apr. 11	Dec. 9			1832
1833							Apr. 9	Dec. 12			1833
1834							Mar. 22	Dec. 17			1834
1835	Mar. 27	Dec. 5					Apr. 4	Dec. 3			1835
1836	Apr. 11	Dec. 11									1836
1837	Mar. 23	Dec. 15					Apr. 17	Jan. 24, 1838			1837
1838	Mar. 24	Dec. 4					Mar. 29	Dec. 5			1838
1839	Mar. 18	Dec. 9					Apr. 7	Dec. 19			1839
1840	Mar. 3	Dec. 6					Mar. 17	[a]			1840
1841	Mar. 24	Dec. 18					[a]	[a]			1841
1842	Mar. 4	Nov. 26					[a]	[a]			1842
1843	Apr. 19	Dec. 6					[a]	[a]			1843
1844	Feb. 29	Dec. 12					[a]	[a]			1844
1845	Mar. 3	[a]					[a]	[a]			1845
1846	[a]	[a]					[a]	[a]			1846
1847	[a]	[a]					[a]	[a]			1847
1848	Mar. 20	Dec. 20					[a]	[a]			1848
1849	Mar. 20	Dec. 25					[a]	[a]			1849
1850	Mar. 2	Dec. 20					[a]	[a]			1850
1851	Feb. 23	Dec. 15					[a]	[a]			1851
1852	Mar. 12	Jan. 5, 1853					[a]	[a]			1852
1853	Mar. 8	Dec. 21					May 9	Nov. 25			1853
1854	Apr. 12	Dec. 3					Apr. 7	Nov. 25			1854
1855	Apr. 5	Dec. 19					May 7	Nov. 30			1855
1856	Apr. 16	Dec. 13					May 6	Dec. 15			1856
1857	Mar. 31	Dec. 16					Apr. 10	Dec. 15			1857
1858	Mar. 23	Dec. 13					Mar. 27	Dec. 31			1858
1859	Mar. 4	Dec. 6					Apr. 2 [b]	Dec. 20			1859
1860	Mar. 9	Nov. 30					Mar. 30	Dec. 3			1860
1861	Feb. 21	Dec. 11					Apr. 8	Dec. 7			1861
1862	Mar. 17	Dec. 24					Mar. 31	Dec. 12			1862
1863	Mar. 30	Dec. 12			Mar. 28		Apr. 10	Dec. 22			1863
1864	Mar. 7	Dec. 17			Mar. 28		Apr. 13	Dec. 2			1864
1865	Mar. 16	Dec. 13			Mar. 28		Apr. 22				1865
1866	Apr. 5	Dec. 7			Apr. 10		Apr. 17	Dec. 7			1866
1867	Apr. 1	Dec. 7			Apr. 8		Apr. 22	Dec. 5			1867
1868	Mar. 19	[a]			Mar. 24		Apr. 13	Dec. 2			1868
1869	[a]	[a]			Apr. 6		May 4	Dec. 7			1869

Dates of opening and closing of navigation at the more important ports on Lakes Erie and Ontario—Continued.

Year.	Sandusky.		Huron.		Cleveland.		Erie.		Buffalo.		Year.
	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	
1870	[a]	[a]			Apr. 8		Apr. 15	Dec. 7			1870
1871	[a]	[a]			Mar. 21		Mar. 25	Dec. 7	Apr. 1	Dec. 27	1871
1872	[a]	Nov. 30			Apr. 8		Apr. 12	Dec. 9	May 5	Dec. 18	1872
1873	Mar. 18	Dec. 22			Apr. 10		Apr. 17	Dec. 6	Apr. 29	Nov. 28	1873
1874	Mar. 7	Dec. 12			Mar. 21		Mar. 28	Dec. 9	Apr. 18	Dec. 5	1874
1875	Apr. 1	Jan. 18, 1876			Apr. 12		Apr. 15	Dec. 10	May 12	Dec. 11	1875
1876	Apr. 1	Dec. 5			Apr. 4		Apr. 7	Dec. 6	May 10	Dec. 17	1876
1877	Mar. 5	Dec. 29			Apr. 10		Apr. 13	Dec. 10	Apr. 26	Dec. 13	1877
1878	Mar. 7	Dec. 18			Mar. 21	Dec. 15	Apr. 6[c]	Dec. 16	Mar. 16	Dec. 7	1878
1879	Mar. 11	Dec. 22			Apr. 1	Dec. 9	Apr. 24	Dec. 13	Apr. 24	Dec. 14	1879
1880	Mar. 6	Dec. 7			Mar. 8	Dec. 13	Apr. 16	Dec. 3	Mar. 19	Dec. 8	1880
1881	Mar. 22	Dec. 15			Apr. 19	Dec. 15	Apr. 27	Dec. 1	May 1	Dec. 30	1881
1882	Feb. 18	Dec. 7			Mar. 14		Mar. 6	Dec. 4	Mar. 26	Dec. 1	1882
1883	Mar. 29	Dec. 15			Apr. 7		Apr. 13	Dec. 1	Apr. 25	Dec. 7	1883
1884	Mar. 18	Dec. 16			Apr. 2		Apr. 5[c]	Dec. 1	Apr. 22	Dec. 6	1884
1885	Mar. 31	Dec. 7			Apr. 17		May 3	Dec. 5	May 2	Dec. 25	1885
1886	Mar. 21	Dec. 2			Mar. 25	Dec. 26	Mar. 30	Dec. 13	Apr. 15	Dec. 15	1886
1887	Apr. 1	Dec. 20			Mar. 8	Dec. 15	Apr. 11	Dec. 1	Apr. 17	Dec. 14	1887
1888	Apr. 9	Dec. 8			Mar. 28	Dec. 8	Apr. 17	Dec. 3	Apr. 28	Dec. 15	1888
1889	Apr. 8	Dec. 6			Mar. 21	Dec. 11	Apr. 12	Dec. 10[c]	Apr. 12	Dec. 14	1889
1890	Mar. 17	Dec. 2			Mar. 1	Dec. 9	Mar. 26[c]	Dec. 30	Mar. 31	Dec. 8	1890
1891	Apr. 7	Dec. 6	Apr. 17	Dec. 27	Mar. 13	Dec. 31	Apr. 6	Jan. 5, 1892	Apr. 16	Dec. 14	1891
1892	Apr. 11	Dec. 8	Apr. 16	Nov. 15	Mar. 27	Dec. 10	Mar. 30	Dec. 7	Apr. 7	Dec. 9	1892
1893	Apr. 10	Dec. 4	Apr. 24	Dec. 24	Mar. 29	Dec. 14	Apr. 1[c]	Dec. 28[c]	Apr. 15	Dec. 16	1893
1894	Apr. 1	Dec. 16	Apr. 6	Nov. 24	Mar. 19	Dec. 31	Mar. 13	Dec. 21	Apr. 1	Dec. 25	1894
1895	Apr. 10	Dec. 16	Apr. 16	Nov. 23	Apr. 4	Jan. 1, 1896	Apr. 6	Dec. 28	Apr. 16	Dec. 1	1895
1896	Apr. 11	Dec. 19	Apr. 22	Dec. 14	Mar. 30	Dec. 12	Apr. 7	Jan. 11, 1897	Apr. 19	Jan. 2, 1897	1896
1897	Mar. 7	Dec. 19	Apr. 7	Dec. 8	Mar. 13	Dec. 19	Mar. 9	Jan. 4, 1898	Apr. 7	Dec. 22	1897
1898	Mar. 6	Dec. 9	Apr. 1	Dec. 2	Mar. 28	Dec. 13	Mar. 9	Dec. 30	Apr. 1	Dec. 21	1898
1899	Mar. 8	Dec. 11	May 10	Dec. 5	Mar. 27	Dec. 13	Mar. 4	Dec. 27[c]	Apr. 27	Dec. 18	1899
1900	Mar. 25	Dec. 15	Apr. 23	Dec. 3	Apr. 9	Dec. 23	Apr. 18	Jan. 4, 1901	Apr. 21	Dec. 20	1900
1901	Mar. 15	Dec. 29	Apr. 11	Dec. 3	Apr. 1	Dec. 14	Apr. 18	Dec. 17	Apr. 18	Jan. 2, 1902	1901
1902	Mar. 6	Dec. 26	Mar. 29	Dec. 8	Mar. 18	Dec. 11	Mar. 28	Dec. 30	Apr. 9	Dec. 31	1902
1903	Mar. 3	Dec. 13	May 16	Dec. 7	Mar. 18	Dec. 2	Mar. 17	Dec. 30	Apr. 1	Dec. 22	1903
1904	Mar. 5	Dec. 13	May 4	Dec. 5	Apr. 5	Dec. 11	Apr. 2	Dec. 23	Apr. 25	Dec. 19	1904
1905	Mar. 11	Dec. 12	Apr. 12	Dec. 5	Apr. 3	Dec. 9	Apr. 1	Dec. 19	Apr. 8	Dec. 19	1905
1906	Feb. 26	Dec. 24	Apr. 4	Dec. 10	Mar. 5	Dec. 16	Mar. 6	Jan. 22, 1907	Mar. 31	Dec. 24	1906
1907	Mar. 11	Dec. 15	Apr. 5	Dec. 6	Mar. 28	Dec. 6	Apr. 1	Jan. 21, 1908	Apr. 6	Dec. 22	1907
1908	Mar. 9		Apr. 1		Apr. 1		Apr. 4[c]		Apr. 25		1908

[a] Date of opening or closing questioned. [b] Doubtful. [c] Fish tug or small boat.

Year.	Fort Niagara.		Charlotte.		North Fair Haven.		Sodus Point.		Oswego.		Year.
	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	Opening.	Closing.	
1875								Dec. 15	Apr. 29		1875
1876							Apr. 1	Dec. 7	Apr. 6		1876
1877							Apr. 5	Jan. 1, 1878	Apr. 23		1877
1878							Mar. 30	Dec. 19	Mar. 9		1878
1879							Apr. 9	Dec. 21	Apr. 9	Dec. 1	1879
1880							Mar. 23		Mar. 21	Dec. 6	1880
1881							Apr. 2	Dec. 16	Mar. 30	Dec. 11	1881
1882							Mar. 24	Dec. 15	Mar. 21	Dec. 5	1882
1883					Apr. 30	Dec. 3	Apr. 4	Dec. 21	Apr. 5	Dec. 11	1883
1884					May 6	Dec. 2	Mar. 28	Dec. 20	Apr. 5	Dec. 13	1884
1885					May 7	Dec. 1	Apr. 23	Dec. 19	May 6	Dec. 16	1885
1886					May 5	Nov. 30	Mar. 30	Dec. 16	Apr. 1	Dec. 9	1886
1887					Apr. 19	Nov. 28	Apr. 7	Dec. 18	Apr. 10	Dec. 16	1887
1888					May 7	Nov. 30	Apr. 10	Dec. 15	Apr. 14	Dec. 10	1888
1889					May 4	Nov. 25	Mar. 26	Dec. 27	Apr. 4	Dec. 18	1889
1890					May 3	Nov. 28	Mar. 16	Dec. 12	Mar. 24	Dec. 13	1890
1891					Apr. 23	Nov. 28	Mar. 28	Dec. 17	Apr. 4	Dec. 28	1891
1892					Apr. 13	Nov. 26	Apr. 1	Dec. 20	Apr. 5	Dec. 17	1892
1893	Apr. 10	Dec. 12			May 4	Nov. 30	Mar. 29	Dec. 12	Apr. 5	Dec. 11	1893
1894	Apr. 1	Dec. 15			Apr. 10	Nov. 24	Apr. 1	Dec. 24	Mar. 30	Dec. 11	1894
1895	Apr. 16	Dec. 18			Apr. 23	Dec. 4	Apr. 12	Dec. 13	Apr. 18	Dec. 10	1895
1896	Apr. 16	Dec. 12			Apr. 17	Nov. 22	Apr. 8	Dec. 20	Apr. 14	Dec. 6	1896
1897	Apr. 5	Dec. 11			Mar. 29	Dec. 22	Mar. 28	Dec. 21	Apr. 5	Dec. 9	1897
1898	Apr. 1	Dec. 12			Apr. 8	Dec. 5	Mar. 16	Dec. 15	Mar. 21	Dec. 15	1898
1899	Apr. 20	Dec. 15			Apr. 24	Dec. 13	Mar. 28	Dec. 25	Apr. 2	Dec. 16	1899
1900	Apr. 20	Dec. 10	Apr. 11	Dec. 12	Apr. 18	Dec. 3	Apr. 5	Dec. 14	Apr. 1	Dec. 12	1900
1901	Apr. 15	Dec. 8	Apr. 10	Dec. 7	Apr. 23	Nov. 30	Apr. 1	Dec. 8	Mar. 31	Dec. 5	1901
1902	Apr. 5	Dec. 15	Apr. 4	Dec. 11	Apr. 4	Nov. 18	Mar. 25	Dec. 18	Mar. 30	Dec. 24	1902
1903	Apr. 1	Dec. 8	Mar. 30	Dec. 7	Apr. 3	Nov. 28	Mar. 21	Dec. 13	Mar. 28	Dec. 4	1903
1904	Apr. 25	Dec. 10	Apr. 12	Dec. 6	Apr. 21	Nov. 24	Apr. 10	Dec. 10	Apr. 20	Dec. 4	1904
1905	Apr. 15	Dec. 8	Apr. 13	Dec. 5	Apr. 14	Nov. 29	Apr. 7	Dec. 15	Apr. 13	Dec. 7	1905
1906	Apr. 12	Dec. 10	Apr. 9	Dec. 15	Apr. 16	Nov. 30	Apr. 9	Dec. 8	Apr. 5	Dec. 8	1906
1907	Apr. 10	Dec. 8	Mar. 31	Dec. 2	Apr. 9	Nov. 29	Mar. 30	Dec. 15	Apr. 8	Dec. 3	1907
1908	Apr. 12		Apr. 11		Apr. 18		Apr. 5		Apr. 9		1908

STUDIES ON THE VORTICES OF THE ATMOSPHERE OF THE EARTH.

By Prof. FRANK H. BIGELOW. Dated May 6, 1908.

III.—THE TRUNCATED DUMB-BELL VORTEX ILLUSTRATED BY THE ST. LOUIS, MO., TORNADO OF MAY 27, 1896.

On the 27th of May, 1896, a large, violent tornado past thru the midst of the city of St. Louis, Mo., doing much damage, and displaying all the features which characterize this class of storms. The meteorological conditions were reported by Dr. H. C. Frankenfield, Local Forecast Official, and an account was published in the MONTHLY WEATHER REVIEW for March, 1896, from which the data used in this paper have been extracted, the same being confirmed by comparison with original records. A study of the mechanical forces exerted upon the buildings which were wrecked, and the St. Louis Bridge which was injured, was made by Mr. Julius Baier, and reported in the Journal of the American Society of Civil Engineers, January and June, 1897. An illustrated phamphlet, by Martin Green, St. Louis, Mo., 1897, gives a graphic description of the numerous destructive effects of the storm. In Table 30 will be found a summary of the meteorological conditions for reference. The vortex proper, apparently lasted from 6 to 6:30 p. m., at the Weather Bureau station, and was central about 6:15 p. m. The barometer oscillated considerably, but the pressure at the station, 29.00 inches, or 737 millimeters (not reduced to sea level), was assumed for the outer radius, ϖ_1. The pressures, temperatures, wind directions, and wind velocities are taken from the automatic records of the Weather Bureau, of which transcripts will be found in Doctor Frankenfield's article.

TABLE 30.—*The meteorological data at St. Louis, Mo., May 27, 1896.*

Time—90th meridian.	Station pressure.	Temperature.	Relative humidity.	Wind. Velocity.	Wind. Direction.	State of sky.
	Inches.	°	%	*mi.p.h.*		
8:00 a. m	29.32	70	94	8	s.	3 S.-Cu.
Noon	29.25	78	....	13	sw.	
2:00 p. m	29.22	84	....	7	se.	8 A.-S.
3:00 p. m	29.17	84	....	10	se.	
4:00 p. m	29.12	84	....	19	se.	10 A.-S.
4:30 p. m	29.10	84	....	18	se.	
5:00 p. m	29.05	81	....	25	se.	10 Cu.
5:10 p. m	29.07	82	....	24	se.	10 Cu.-N.
5:20 p. m	29.07	81	....	22	se.	10 N.
5:30 p. m	29.05	80	....	23	se.	10 N.
5:40 p. m	29.05	79	....	30	se.	10 N.
5:50 p. m	29.04	77	100	19	e.	10 N.
6:00 p. m	28.97	72	....	44	ne.	10 N.
6:10 p. m	28.97	....	....	38	se.	10 N.
6:20 p. m	28.74	....	....	80	nw.	10 N.
6:30 p. m	29.14	....	....	34	n.	10 N.
6:40 p. m	29.14	....	....	16	ne.	10 N.
6:50 p. m	29.10	....	....	7	ne.	10 N.
7:00 p. m	29.05	67	....	17	e.	10 N.
8:00 p. m	29.16	65	100	10	n.	
9:00 p. m	29.18	....	....	....	....	
10:00 p. m	29.14	66	....	....	....	

The vortex was central about 6:15 p. m.

An aneroid barometer, read by the son of Mr. Klemm, on the south side of Lafayette Park near the center of the storm, indicated 680 millimeters = 26.78 inches. This checks in reading 677 millimeters obtained by the vortex rings.

TABLE 31.—*Adopted pressure on the center of the path of the tornado.*

Time.	Pressure. Inches.	Pressure. mm.	Position.
6:00 p. m....	29.00	737	Edge of vortex, ϖ_1
	28.62	727	ϖ_2
	28.23	717	ϖ_3
	27.84	707	ϖ_4
	27.44	697	ϖ_5
	27.05	687	ϖ_6
6:15 p. m....	26.65	677	Center of vortex, ϖ_7

THE DATA FOR COMPUTING THE VORTEX.

The tornado past over the city from west to east, and apparently the center of the vortex crost Lafayette Park, whence it proceeded to the great bridge spanning the Mississippi River. The Weather Bureau office is about seven blocks north of the park, and it was estimated that the vortex was about one and one-fourth miles wide. It is necessary to determine at what chord the instruments of the Weather Bureau crost the vortex tubes, so that the records may be suitably interpreted. By a careful study of the De Witte typhoon, in which case the meteorological data sufficed to determine several of the individual isobars, from which the ratio of the successive radii could be found, it was possible to construct a vortex diagram suitable to the atmosphere. This same scale of vortex was adopted for the St. Louis tornado, as the data to construct a complete vortex independently were lacking, and it was only necessary to find the pressure and the wind direction and velocity at a few points. The pressure, 29.00 inches (737 millimeters) was taken for ring ϖ_1, and the successive rings were given a pressure diminishing by 10 millimeters, until the seventh ring ϖ_7, was found with a pressure of 26.65 inches (677 millimeters) near the center of the vortex.

The following note appears in Doctor Frankenfield's paper, added June 23, 1896:

> I have just learned of the height of the barometer, within a reasonable degree of accuracy, in or very near the center of the track of the tornado at the time it moved thru Lafayette Park. It was in this park that the storm was at its height. An aneroid barometer, with a metrical scale, was brought to me to be reset, and I was informed that it was the property of the widow of the late Richard Klemm, ex-Park Commissioner of the city. The family live on Missouri avenue, immediately fronting the park, and a son of Mr. Klemm read the barometer as the storm struck their place. He called the attention of his mother to the remarkably low reading, 680 millimeters, or 26.78 inches. Allowing for difference in elevation and reduction to sea level, this would indicate a reduced reading of 27.30 inches, or 2.05 inches lower than observed at this office.

If the barometric pressure was 26.65 inches near the center, the pressure at the Weather Bureau office would be 26.65 + 2.05 = 28.70 inches. As the observation gave 28.74 inches, we may suppose that the office passed near or within the ϖ_2 circle. I have taken it somewhat within this circle, because the Klemm house was a little south of the central line of the vortex as marked by the débris, and it is probable that its position is between circles ϖ_6 and ϖ_7.

TABLE 32.—*Table of observed wind velocities near the vortex center.*

Time, p. m.	Wind. Velocity.	Wind. Direction.
	mi.p.h.	
5:50–5:55	37	e.
5:55–6:00	44	ne.
6:00–6:05	28	se.
6:05–6:10	38	se.
6:10–6:15	60	nw.
6:15–6:20	80	nw.
6:20–6:25	44	ne.

It appears from Table 32 that the wind velocity between 5:50 and 6:05 p. m. averaged about 33 miles per hour, and that it averaged 56 miles per hour from 6:05 to 6:25 p. m. There were great oscillations in the wind velocity, the maximum for less than one minute being 120 miles per hour at 6:18 p. m. A study of the wind directions in all possible detail shows that the wind cut the isobars at about 30°, so that the angle $i = -30°$, whence, by the formula $az = 90° + i$, the angular altitude $az = 60°$. These values are adopted for the computations on the vortex.

On the isobar whose radius $= \varpi_1$, $q_1 = 33$ miles per hour.
$i = -30°$.

On the isobar whose radius$=\varpi_2$, $q_2=56$ miles per hour.
$i=-30°$.

Adopting the values $q_1=33$ miles per hour=15 meters per second on ϖ_1, and $q_2=56$ miles per hour=25 meters per second on ϖ_2, we obtain the following:

Tube.	(1)	(2)	
$\varpi=$	960 m.	600 m.	Adopted radii.
$u=q\sin i$..................	−7.5	−13.0	Adopted radial velocities.
$v=q\cos i$....................	12.5	21.6	Adopted tangential velocities.

It is intended to compute the average vortex at the outset, and then to discuss it by applying the proper formulas and the divergences between the angles and velocities in the mean vortex and that occurring in nature. The mode of constructing this mean vortex from a few available observations will be given in detail. The formulas for this type of vortex are repeated here for convenience.

GENERAL FORMULAS.

$$v\varpi = a\psi = Aa\varpi^2 \sin az.$$

$$u = -\frac{1}{\varpi}\frac{\partial\psi}{\partial z} = -Aa\varpi \cos az.$$

$$v = \frac{a\psi}{\varpi} = Aa\varpi \sin az.$$

$$w = +\frac{1}{\varpi}\frac{\partial\psi}{\partial\varpi} = +2A \sin az.$$

The first step is to scale from the diagram on the adopted radius, $\varpi_1=960$ meters, the length of the other radii.

TABLE 33.—*Computation of the mean $(v\varpi)=a\psi$.*

Term.	Number.	Logarithm.	Term.	Number.	Logarithm.
ϖ_1	960	2.98227	ϖ_2	600	2.77815
v_1	13	1.11394	v_2	21	1.32222
u_1	8	....	u_2	13	....
$(v\varpi)_1$	.....	4.09621	$(v\varpi)_2$	.....	4.10037
Mean $(v\varpi)$	12 554	4.09879			

Then take $\log \varpi_n$ and the successive differences, $\log \rho = \log \varpi_n - \log \varpi_{n+1}$; compute the mean $\log \rho=0.20546$; construct $\log (v\varpi)_1=4.09621$ and $\log (v\varpi)_2=4.10037$; the mean $\log (v\varpi)=\log a\psi=4.09879$, and this is the constant to be laid at the basis of the vortex. In this case we assumed $(v\varpi)_1=13\times 960$ and $(v\varpi)_2=21\times 600$, taking approximate values. If more observed velocities are at hand, the value of $\log a\psi$=constant can be made more accurate. Finally, from $\log \varpi_1$ we compute $\log \varpi_2$, $\log \varpi_3$, etc., by subtracting 0.20546 in succession, whence the values in Table 34.

TABLE 34.—*Computation of the mean $\log \rho$ and the radii ϖ_n.*

B.	ϖ	$\log\varpi$	$\log\rho$	$\log \varpi_n$	ϖ_n	Tubes.
Mm.	*Meters.*				*Meters.*	
787	960	2.98227		2.98227	960.0	ϖ_1
			0.20412			
727	600	2.77815		2.77681	598.2	ϖ_2
			0.20412			
717	375	2.57403		2.57135	372.7	ϖ_3
			0.19382			
707	240	2.38021		2.36589	232.2	ϖ_4
			0.23408			
697	140	2.14613		2.16043	144.7	ϖ_5
			0.19189			
687	90	1.95424		1.95497	90.2	ϖ_6
			0.21388			
677	55	1.74036		1.74951	56.2	ϖ_7
			0.19629			
667	35	1.54407		1.54405	35.0	ϖ_8
		Mean $\log\rho$=	0.20546			

In order to determine the angular constant a, it was assumed that the effective cloud forming the tornado was 1,200 meters above the surface, and that consequently 600 meters had been cut off from the vortex tube, because $az=60°$ was below the surface, since $i=-30°$ at the surface on the horizontal plane as shown in Chart IX, fig. 6.

$$\text{Hence, } a = \frac{180°}{1200+600} = \frac{180°}{1800} = 0.10°.$$

We compute the velocity components on the plane $az=60°$ as follows:

For $az=60°$,

$\log \sin az = \log \sin 60° = 9.93753$
$\log \cos az = \log \cos 60° = 9.69897$

For $a=0.10°$,

$\log a = \log 0.10° = 9.00000$

hence,

$\log a \sin az = 8.93753$
$\log a \cos az = 8.69897$

which are constants for $az=60°$, or $i=-30°$.

TABLE 35.—*Computation of A, u, v, w for each radius ϖ_n, $az=60°$.*

Term.	ϖ_1	ϖ_2	ϖ_3	ϖ_4	ϖ_5	ϖ_6	ϖ_7
$\log\varpi$	2.98227	2.77681	2.57135	2.36589	2.16043	1.95497	1.74951
$\log v$	1.11652	1.32198	1.52744	1.73290	1.93836	2.14382	2.34928
v	13.1	21.0	33.7	54.1	86.8	139.3	223.5
$\log a\varpi \sin az$	1.91980	1.71434	1.50888	1.30342	1.09796	0.89250	0.68704
$\log A$	9.19672	9.60764	0.01856	0.42948	0.84040	1.25132	1.66224
A	0.1573	0.4052	1.0437	2.6883	6.9247	17.8371	45.9450
$\log u$	−0.87796	−1.08342	−1.28888	−1.49434	−1.69980	−1.90526	−2.11072
u	−7.6	−12.1	−19.5	−31.2	−50.1	−80.4	−129.0
$\log w$	9.43528	9.84620	0.25712	0.66804	1.07896	1.48988	1.90080
w	0.27	0.70	1.81	4.66	11.99	30.89	79.58
$\log Aa\varpi$	1.17899	1.38445	1.58991	1.79537	2.00083	2.20629	2.41175
$Aa\varpi$	15.10	24.24	38.90	62.43	100.19	160.80	258.08

The successive values of $\log \varpi_n$ in Table 35 are formed by subtracting 0.20546; the values of $\log v$ are formed by adding 0.20546 to $\log v_1$, or by subtracting the successive $\log \varpi_n$ from $\log a\psi = 4.09879$. The values of $\log a\varpi \sin az$ are formed by adding 8.93753 to the successive $\log \varpi_n$. To obtain $\log A_n$ subtract the successive values of $\log a\varpi_n \sin az$ from the successive $\log v_n$. To compute the values of $\log u_n$ add $\log a \cos az$, $\log \varpi$, and $\log A$. The values of $\log w_n$ are found from $2A \sin az$.

TABLE 36.—*The logarithms of quantities useful in computing ϖ_1, u_1, v_1, w_1, on the 10-degree levels.*

Angle az.		$\sin az$.	Diff.	½ Diff.	$\cos az$.	$Aa\varpi$.	$2A$.
°	°						
$az=$ 0	180	$-\infty$			0.00003	∞	
			....	....			
10	170	9.23967			9.99335	1.52792	9.49775
			0.29438	0.14719			
20	160	9.53405			9.97299	1.38073	9.49775
			0.16492	0.08246			
30	150	9.69897			9.93753	1.29827	9.49775
			0.10910	0.05455			
40	140	9.80807			9.88425	1.24372	9.49775
			0.07618	0.03809			
50	130	9.88425			9.80807	1.20563	9.49775
			0.05328	0.02664			
60	120	9.93753			9.69897	1.17899	9.49775
			0.03546	0.01773			
70	110	9.97299			9.53405	1.16126	9.49775
			0.02036	0.01018			
80	100	9.99335			9.23967	1.15108	9.49775
			0.00665	0.00333			
90	90	0.00000			$-\infty$	1.14775	9.49775

The difference of the successive values of $\log \varpi$ is equal to $-\log \rho$; of $\log v$ is $+\log \rho$; of $\log A$ is $+2\log \rho$; of $\log u$ is $+\log \rho$, and of $\log w$ is $+2\log \rho$. Checks on the computation can be readily formed from these precepts.

COMPUTATION OF ϖ_n, u_n, v_n, w_n ON OTHER LEVELS.

The computation of the radii, the radial, tangential, and vertical velocities on other levels, as for $az = 60°, 70°, 80°, 90°, \ldots\ldots 180°$, is accomplished by using the proper trigonometric functions as called for by the formulas. In extending the logarithms to the 10-degree levels, Table 36 will be found useful. Since $a\psi = Aa\varpi^2 \sin az$, we have

$$\varpi = \left(\frac{a\psi}{Aa \sin az}\right)^{\frac{1}{2}} \tag{54}$$

as the formula for computing log ϖ.

If ϖ is computed for the level $az = 60°$, it can be extended to the other levels by using the column $\frac{1}{2}$ diff. $= \frac{1}{2}[\log \sin az - (\sin az \pm 10°)]$.

Table 37 contains the values of log ϖ and ϖ, the radii of the different levels of the seven vortex tubes.

TABLE 37.—*Computation of log ϖ and ϖ, for each tube at successive altitudes.*

Value of log ϖ.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$az = 180°$	∞	∞	∞	∞	∞	∞	∞
170	3.33120	3.12574	2.92028	2.71482	2.50936	2.30390	2.09844
160	3.18401	2.97855	2.77309	2.56763	2.36217	2.15671	1.95125
150	3.10155	2.89609	2.69063	2.48517	2.27971	2.07425	1.86879
140	3.04700	2.84154	2.63608	2.43062	2.22516	2.01970	1.81424
° 130	3.00891	2.80345	2.59799	2.39253	2.18707	1.98161	1.77615
60 120	2.98227	2.77681	2.57135	2.36589	2.16043	1.95497	1.74951
70 110	2.96454	2.75908	2.55362	2.34816	2.14270	1.93724	1.73178
80 100	2.95436	2.74890	2.54344	2.33798	2.13252	1.92706	1.72160
90 90	2.95103	2.74557	2.54011	2.33465	2.12919	1.92373	1.71827

The radius $\varpi = \left(\frac{a\psi}{Aa \sin az}\right)^{\frac{1}{2}}$.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$az = 180°$	∞	∞	∞	∞	∞	∞	∞
170	2143.9	1335.8	832.3	518.6	323.1	201.3	125.4
160	1527.6	951.8	593.0	369.5	230.2	143.5	89.4
150	1263.4	787.2	490.5	305.6	190.4	118.6	73.9
140	1114.3	694.3	432.5	269.5	167.9	104.6	65.2
° 130	1020.7	636.0	396.3	246.9	153.8	95.9	59.7
60 120	960.0	598.1	372.7	232.2	144.7	90.2	56.2
70 110	921.6	574.2	357.8	222.9	138.9	86.5	53.9
80 100	900.2	560.9	349.5	217.8	135.7	84.5	52.7
90 90	893.4	556.6	346.8	216.1	134.6	83.3	52.3

THE VELOCITIES IN THE ST. LOUIS TORNADO.

TABLE 38.—*The computation of radial velocities u, for each tube and altitude.*

Values of log u.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$az = 180°$	∞	∞	∞	∞	∞	∞	∞
170	1.52127	1.72673	1.93219	2.13765	2.34311	2.54857	2.75403
160	1.35372	1.55918	1.76464	1.97010	1.17556	2.38102	2.58648
150	1.23580	1.44126	1.64672	1.85218	2.05764	2.26310	2.46856
140	1.12797	1.33343	1.53889	1.74435	1.94981	2.15527	2.36073
° 130	1.01370	1.21916	1.42462	1.63008	1.83554	2.04100	2.24646
60 120	0.87796	1.08342	1.28888	1.49434	1.69980	1.90526	2.11072
70 110	0.69531	0.90077	1.10623	1.31169	1.51715	1.72261	1.92807
80 100	0.39075	0.59621	0.80167	1.00713	1.21259	1.41805	1.62351
90 90	−∞	−∞	−∞	−∞	−∞	−∞	−∞

Values of the radial velocity, $u = -Aa\varpi \cos az$.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$az = 180°$	∞	∞	∞	∞	∞	∞	∞
170	33.2	53.3	85.5	137.3	220.3	353.6	567.6
160	22.6	36.2	58.2	93.4	149.8	240.4	385.9
150	17.2	27.6	44.3	71.2	114.2	183.3	294.1
140	13.4	21.6	34.6	55.5	89.1	143.0	229.5
130	10.3	16.6	26.6	42.7	68.5	109.9	176.4
120	7.6	12.1	19.5	31.2	50.1	80.4	129.0
110	5.0	8.0	12.8	20.5	32.9	52.8	84.7
100	2.5	4.0	6.3	10.2	16.3	26.2	42.0
90	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	− 2.5	− 4.0	− 6.3	−10.2	−16.3	−26.2	− 42.0
70	− 5.0	− 8.0	−12.8	−20.5	−32.9	−52.8	− 84.7
60	− 7.6	−12.1	−19.5	−31.2	−50.1	−80.4	−129.0

TABLE 39.—*The computation of the tangential velocities for each tube and altitude.*

Values of log v.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$az = 180°$	—	—	—	—	—	—	—
170	0.76759	0.97305	1.17851	1.38397	1.58943	1.79489	2.00035
160	0.91478	1.12024	1.32570	1.53116	1.73662	1.94208	2.14754
150	0.99724	1.20270	1.40816	1.61362	1.81908	2.02454	2.23000
140	1.05179	1.25725	1.46271	1.66817	1.87363	2.07909	2.28455
° 130	1.08988	1.29534	1.50080	1.70626	1.91172	2.11718	2.32264
60 120	1.11652	1.32198	1.52744	1.73290	1.93836	2.14382	2.34928
70 110	1.13425	1.33971	1.54517	1.75063	1.95609	2.16155	2.36701
80 100	1.14443	1.34989	1.55535	1.76081	1.96627	2.17173	2.37719
90 90	1.14776	1.35322	1.55868	1.76414	1.96060	2.17506	2.38052

Values of the tangential velocity, $v = Aa\varpi \sin az$.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$az = 180°$	0	0	0	0	0	0	0
170	5.9	9.4	15.1	24.2	38.9	62.4	100.1
160	8.2	13.2	21.2	34.0	54.5	87.5	140.5
150	9.9	16.0	25.6	41.1	65.9	105.8	169.8
140	11.3	18.1	29.0	46.6	74.8	120.0	192.6
° 130	12.3	19.7	31.7	50.9	81.6	131.0	210.2
60 120	13.1	21.0	33.7	54.1	86.8	139.3	223.5
70 110	13.6	21.9	35.1	56.3	90.4	145.1	232.8
80 100	13.9	22.4	35.9	57.7	92.5	148.5	238.3
90 90	14.1	22.6	36.2	58.1	93.2	149.6	240.2

TABLE 40.—*The computation of the vertical velocities w, for each tube and altitude.*

Values of log w.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$az = 180°$	−∞	−∞	−∞	−∞	−∞	−∞	−∞
170	8.73742	9.14834	9.55926	9.97018	0.38110	0.79202	1.20294
160	9.03180	9.44272	9.85364	0.26456	0.67548	1.08640	1.49732
150	9.19672	9.60764	0.01856	0.42948	0.84040	1.25132	1.66224
140	9.30582	9.71674	0.12766	0.53858	0.94952	1.36044	1.77136
° 130	9.38200	9.79292	0.20384	0.62476	1.03568	1.44660	1.85752
60 120	9.43528	9.84620	0.25712	0.66804	1.07896	1.48988	1.90080
70 110	9.47074	9.88166	0.29258	0.70350	1.11442	1.52534	1.93626
80 100	9.49110	9.90202	0.31294	0.72386	1.13478	1.54570	1.95662
90 90	9.49775	9.90867	0.31959	0.73051	1.14143	1.55235	1.96327

Values of the vertical velocity, $w = 2A \sin az$.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$az = 180°$	0	0	0	0	0	0	0
170	0.06	0.14	0.36	0.93	2.41	6.20	15.96
160	0.11	0.28	0.71	1.84	4.74	12.20	31.43
150	0.16	0.41	1.04	2.69	6.93	17.84	45.94
140	0.20	0.52	1.34	3.46	8.90	22.93	59.07
° 130	0.24	0.62	1.60	4.22	10.86	27.96	72.03
60 120	0.27	0.70	1.81	4.66	11.99	30.90	79.58
70 110	0.30	0.76	1.96	5.05	13.01	33.52	86.35
80 100	0.31	0.80	2.06	5.30	13.64	35.13	90.49
90 90	0.32	0.81	2.09	5.38	13.85	35.67	91.89

THE HORIZONTAL ANGLE i AND VERTICAL ANGLE η OF THE CURRENT q IN THE ST. LOUIS TORNADO.

The horizontal angle i is directed inward from $az = 60°$ to $az = 90°$ and outward from $az = 90°$ to $az = 180°$. The angle i is calculated by the formula $\tan i = \frac{u}{v}$. Table 41 gives the value of i at 10° intervals for each tube.

TABLE 41.—*The horizontal angle i, negative inward, positive outward.*

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$az = 180°$	90°	90°	90°	90°	90°	90°	90°
170	80	80	80	80	80	80	80
160	70	70	70	70	70	70	70
150	60	60	60	60	60	60	60
140	50	50	50	50	50	50	50
130	40	40	40	40	40	40	40
120	30	30	30	30	30	30	30
110	20	20	20	20	20	20	20
100	10	10	10	10	10	10	10
90	0	0	0	0	0	0	0
80	−10	−10	−10	−10	−10	−10	−10
70	−20	−20	−20	−20	−20	−20	−20
60	−30	−30	−30	−30	−30	−30	−30

TABLE 42.—*Vertical angle η, positive upward.*

$$\tan \eta = \frac{w}{v \sec i}.$$

Altitude.	(1)		(2)		(3)		(4)		(5)		(6)		(7)	
°	°	′	°	′	°	′	°	′	°	′	°	′	°	′
az = 180	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170	0	6	0	9	0	14	0	23	0	37	0	59	1	35
160	0	15	0	25	0	40	1	4	1	42	2	44	4	22
150	0	27	0	44	1	10	1	52	3	0	4	49	7	42
140	0	40	1	4	1	42	2	44	4	23	7	0	11	9
° 130	0	52	1	23	2	13	3	38	5	49	9	17	14	43
60 120	1	2	1	39	2	40	4	16	6	50	10	53	17	8
70 110	1	10	1	52	3	0	4	49	7	42	12	15	19	13
80 100	1	15	2	1	3	14	5	10	8	16	13	7	20	30
90 90	1	17	2	3	3	18	5	17	8	27	13	25	20	50

The total velocity q, in meters per second, can be computed from the formula

$$q = v \sec i \sec \eta$$

and the resulting values are given in Table 43.

TABLE 43.—*Total velocity q, in meters per second.*

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
°							
az = 180	∞	∞	∞	∞	∞	∞	∞
170	33.72	54.12	86.86	139.42	223.76	359.17	576.57
160	24.03	38.57	61.90	99.35	159.50	256.17	411.86
150	19.87	31.90	51.20	82.20	132.04	212.38	342.74
140	17.53	28.14	45.17	72.54	116.64	188.05	305.32
° 130	16.06	25.78	41.39	66.51	107.08	173.25	283.71
60 120	15.10	24.25	38.94	62.60	100.91	163.75	270.06
70 110	14.30	23.28	37.39	60.14	97.06	157.97	262.38
80 100	14.16	22.74	36.53	58.78	94.94	154.94	258.38
90 90	14.06	22.57	36.26	58.34	94.26	153.84	257.14

We begin with $q = 15$ meters per second on the outer tube 1 and $q_2 = 25$ meters per second on the second tube, and it is seen that the total velocity on the lowest section of the St. Louis tornado reaches 164 meters per second on tube 6 and 270 meters per second on tube 7, near the axis. These are the velocities of the wind which caused the destructive effects in passing over the city. Chart X, fig. 7, gives the geometrical form of a section in the vertical plane $z\,\varpi$, of the tubes forming the St. Louis vortex. It shows that it was truncated at the plane $az = 60°$, and that in the topmost levels it overspread the base. These upper branches appear actually in nature as the turbulent cloud motions which precede and follow the storm center in the cumulus levels.

The volume of air V, in cubic meters per second, which passes upward thru each vortex tube, is computed from the formula,

$$V = \pi(\varpi_n^2 - \varpi^2_{n+1})\, w_n.$$

The results are shown in Table 44.

TABLE 44.—*Volume of air ascending in each vortex tube.*

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
°							
az = 10	774500	774500	774500	774500	774500	774500	774500
30	774500	774500	774500	774500	774500	774500	774500
90	774500	774500	774500	774500	774500	774500	774500

This table shows that 774,500 cubic meters of air is passing upward thru each ring area per second. Since the Cottage City waterspout was carrying upward about 16,452 cubic meters of air per second, it follows that the *St. Louis tornado was about 47.08 times as efficient in lifting the air as was the Cottage City waterspout*, this being due to its greater dimensions.

EVALUATION OF THE FIRST EQUATION OF MOTION.

The pressure change on the horizontal plane is given by the first equation of motion, because the pressure has been assumed not to vary along the circles whose radii are ϖ_n. The full form of the equation is,

$$-\frac{\partial P}{\rho \partial \varpi} = \frac{\partial u}{\partial t} + u\frac{\partial u}{\partial \varpi} + w\frac{\partial u}{\partial z} - \frac{v^2}{\varpi} - 2\,n\cos\theta\cdot v + ku,$$

$$= \frac{\partial u}{\partial t} + A^2 a^2 \varpi - 2\,n\cos\theta\cdot v + ku.$$

All these terms can be computed with precision, except the friction term ku, and some idea of the value of the friction coefficient may even be obtained.

The inertia term $\frac{\partial u}{\partial t}$.

In computing the inertia it is first necessary to find the time of the movement of the air between the successive rings, and the computation is given in full, as an example. The term can be found from any component, and that of the radial velocity is the most convenient to employ for this purpose. Find the mean u_m and the difference of the radii $\varpi_n - \varpi_{n+1}$ in succession, then,

$$\partial t = \frac{u_m}{\varpi_n - \varpi_{n+1}}. \tag{55}$$

Next compute in succession, $\partial u = u_n - u_{n+1}$, so that

$$\frac{\partial u}{\partial t} = \frac{u_m (u_n - u_{n+1})}{\varpi_n - \varpi_{n+1}}. \tag{56}$$

This is performed in Table 45.

TABLE 45.—*The computation of* $\frac{\partial u}{\partial t}$.

Term.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\log u$	0.87796	1.08342	1.28088	1.49434	1.69980	1.90526	2.11072
$\log u_m$	0.98069	1.18615	1.39161	1.59707	1.80253	2.00799	
ϖ	960.0	598.0	372.7	232.2	144.7	90.2	56.2
$\varpi_n - \varpi_n+1$	361.9	225.4	140.5	87.5	54.5	34.0	
$\log(\varpi_n - \varpi_n+1)$	2.55859	2.35295	2.14768	1.94201	1.73640	1.53148	
$\log \partial t$	1.57790	1.16680	0.75607	0.34494	9.93387	9.52349	
∂t	37.84	14.68	5.70	2.21	0.86	0.334	
u	−7.6	−12.1	−19.5	−31.2	−50.1	−80.4	−129.0
$u_n - u_n+1$	4.5	7.4	11.7	18.9	30.3	48.6	
$\log(u_n - u_n+1)$	0.65321	0.86923	1.06817	1.27646	1.48144	1.68644	
$\log \frac{\partial t}{\partial u}$	9.07531	9.70243	0.31212	0.93152	1.54757	2.16315	
$\frac{\partial t}{\partial u}$	0.119	0.504	2.052	8.541	35.283	144.60	

Similarly, the values of $\frac{\partial v}{\partial t}$ and $\frac{\partial w}{\partial t}$ are to be found as computed in Tables 46 and 47.

TABLE 46.—*Computation of the tangential inertia* $= \frac{\partial v}{\partial t}$.

Term.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
v	13.1	21.0	33.7	54.1	86.8	139.3	223.5
$v_n - v_{n+1}$	7.9	12.7	20.4	32.7	52.5	84.2	
$\frac{\partial v}{\partial t}$	0.209	0.865	3.577	14.778	61.135	252.24	

TABLE 47.—*Computation of the vertical inertia* $= \frac{\partial w}{\partial t}$.

Term.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
w	0.27	0.70	1.81	4.66	11.99	30.90	79.58
$w_n - w_{n+1}$	0.43	1.11	2.85	7.33	18.91	48.68	
$\frac{\partial w}{\partial t}$	0.011	0.076	0.500	3.313	22.020	145.83	

The deflecting forces.

The radial deflecting force, $-2n\cos\theta \cdot v_m$, and the tangential deflecting force, $+2n\cos\theta \cdot u_m$, are computed in Tables 48 and 49, using the mean values of v_m, u_m, computed thru their logarithms.

TABLE 48.—*Computation of the radial deflecting force,* $-2n\cos\theta \cdot v_m$.

$\phi = 38° 38'$. $\theta = 51° 22'$.

Term.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
log v	1.11652	1.32198	1.5.744	1.73290	1.93836	2.14382	2.34928
log $2n\cos\theta \cdot v$	7.07582	7.28128	7.48674	7.69220	7.89766	8.10312	8.30858
log $2n\cos\theta \cdot v_m$	7.17855	7.38401	7.58947	7.79493	8.00039	8.20585	
$-2n\cos\theta \cdot v_m$	−0.002	−0.002	−0.004	−0.006	−0.010	−0.016	

TABLE 49.—*Computation of the tangential deflecting force,* $+2n\cos\theta \cdot u_m$.

Term.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
log u	0.87796	1.08342	1.28888	1.49434	1.69980	1.90526	2.11072
$2n\cos\theta \cdot u$	0.001	0.001	0.002	0.004	0.006	0.009	

The fall in pressure between the successive vortex rings.

The fall in pressure, ΔP, between the successive rings ϖ_1, ϖ_2, . ., is computed by the formula,

$$\Delta P = \rho_m (\varpi_n - \varpi_{n+1}) \left[(A^2 a^2 \varpi)_m + \frac{\partial u}{\partial t} - 2\, n\cos\theta \cdot v_m + k u_m \right]$$

and this is performed in Table 49.

The result of the computation of $A^2 a^2 \varpi$ is given in Table 50, and all the other terms, except the friction coefficients, are brought together in the line marked Sum. This is to be multiplied by $\rho_m\ (\varpi_n - \varpi_{n+1})$ to give successive values of ΔP, the difference in pressure from one ring to another exprest in mechanical units. This is reduced to barometric pressure in millimeters by the formula,

$$\Delta B = \Delta P \times 0.0075.$$

If we again assume that the pressure on ring ϖ_1 is 737.0 millimeters, then the line marked B_c (Table 50) gives the barometric pressure as computed on the successive rings ϖ_1, ϖ_2, ϖ_3, . . ϖ_7. These values when plotted on a diagram, give a pressure-curve resembling a funnel-shaped vortex, which is apparently the shape of the pressure curve within the dumb-bell-shaped vortex. Altho we have no actual observations of pressure to guide us, it is yet possible to suppose that the observed pressures in the outer portions of the vortex decreased by 10 millimeters-differences on the rings ϖ_1, ϖ_2, ϖ_3, ϖ_4, giving 737, 727, 717, 707 millimeters in place of the computed pressures 737.0, 735.1, 730.2, 718.5. The differences +8.1, +13.2, +11.5, may possibly be due to the effect of friction on the tube, i. e., the tube in passing over the city, may be distorted in its lowest section by its work of destruction on the houses. Those values of $\Delta B = B_c - B_0$ reduced to ΔP, become 1080, 1760, 1533. Now the value of the coefficient of friction, k, should be found from,

$$k = \frac{\Delta P}{u_m (\varpi_n - \varpi_{n+1})}, \tag{57}$$

and for the mean value of $\Delta P = 1458$, we find $k = 0.2867$. This value for the coefficient of friction may not be very exact, because we lack observed values of B, but it illustrates a method of computing k which can be applied in the study of hurricanes, ocean and land cyclones.

TABLE 50.—*Computation of the fall in pressure, ΔP, between the successive vortex rings.*

Term.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$A^2 a^2 \varpi$	0.238	0.982	4.059	16.782	69.380	286.82	1185.75
$(A^2 a^2 \varpi)_m$	0.483	1.997	8.254	34.122	141.07	583.18	
$\frac{\partial u}{\partial t}$	0.119	0.504	2.052	8.541	35.28	145.60	
$-2n\cos\theta \cdot v$	−0.002	−0.002	−0.004	−0.006	−0.010	−0.02	
Sum	0.600	2.499	10.302	41.657	176.44	728.76	
log Sum	9.77815	0.39777	1.01292	1.62999	2.24635	2.86259	
ϖ_n	960.0	598.1	372.7	232.2	144.7	90.2	56.2
$\varpi_n - \varpi_{n+1}$	361.9	225.4	130.5	87.5	54.5	34.0	
log $(\varpi_n - \varpi_{n+1}$	2.55859	2.35295	2.11561	1.94201	1.73640	1.53148	
ρ_m	0.06608	0.06608	0.06608	0.06608	0.06608	0.06608	
log ΔP	2.40282	2.81680	3.19461	3.63808	4.04883	4.46015	
log ΔB	0.27788	0.69186	1.06967	1.51314	1.92389	2.33521	
ΔB (in mm.)	1.90	4.92	11.74	32.59	83.92	216.38	
FRICTION COEFFICIENTS.							
B_c	737.0	735.1	730.2	718.5	685.9	602.0	385.6
B_o	737.0	727.0	717.0	707.0	697.0	687.0	677.0
$B_c - B_o$	0.0	+8.1	+13.2	+11.5	−11.1	−85.0	−291.4
ΔP	....	1080	1760	1533	1480	....	....
$u_m (\varpi_n - \varpi_{n+1}) \rho_m$	....	5106	5104	5106	5104	....	....
k	....	0.2115	0.3448	0.3003	0.2900	....	....

THE CAUSE OF THE DESTRUCTIVE EFFECTS IN THE ST. LOUIS TORNADO.

After the passage of the tornado over the city of St. Louis it was found that immensely powerful forces of destruction had been in operation. Trees had been uprooted, their tops had been twisted off at the trunk, large buildings had been wrecked in every conceivable way, heavy stones and irons had been moved bodily, iron girders had been twisted and torn, a plank had been driven thru the webbing of a steel girder of the bridge, and numberless instances of powerful forces in operation are on record. We can compute[1] the values of the pressure differences between successive vortex rings from the formula,

$$\Delta B = 0.001742 \frac{B}{T} q^2, \tag{58}$$

where ΔB is the pressure difference exprest in millimeters, T is the absolute temperature, and q is the wind velocity in meters per second.

The resulting computation and values of ΔB are given in Table 51.

It was observed that the destructive effects of the tornado seem to diminish greatly at a plane about 30 feet above the ground, the second and upper stories of the buildings suffering much more than the first story. This implies that the vertical forces in the tube were cut off at that plane by the disturbing frictional resistances of the rough surface of the city. An inspection of the pressures developed by the wind having a velocity q, shows that in the center of the vortex the pressure can, theoretically, run up to about 8,000 pounds per

[1] See Monthly Weather Review, October, 1906, XXXIV, p. 470, formula (11).

square foot, and the wind velocity can reach 270 meters per second, or 600 miles per hour. Whatever may be thought as to the actual development of such velocities and forces in this tornado, it is evident that sufficient power has been revealed to account fully for all the mechanical forces that were observed and considered by engineers. Mr. Julius Baier thought that something like 100 pounds per square foot had been expended in the destructive effects, but it is evident that much greater forces were really available near the center of the tube. At some distance from the center, in the tubes $\varpi_3=375$ meters to $\varpi_4=240$ meters, the pressures were apparently from 175 to 450 pounds per square foot. The subordinate minor whirls, or small vortices caused by the wind twining around obstacles, builds up the so-called frictional coefficient. In the free air the value of k is apparently a negligible quantity, and large values of k are confined to a thin surface layer.

TABLE 51.—*Approximate pressure in pounds per square foot exerted by the wind in the St. Louis tornado.*

$$\Delta B = 0.001742 \frac{B}{T} q^2.$$

Tubes.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
q	15.10	24.25	38.94	62.60	100.91	163.75	270.06
B	0.737	0.727	0.717	0.707	0.697	0.689	0.677
T	294.	294.	294.	294.	294.	294.	294.
ΔB (mm.)	9.96	25.33	64.42	164.16	420.33	1091.5	2925.6
$\Delta B \left(\frac{\text{pounds}}{\text{foot}^2}\right)$	27.66	70.37	178.96	456.03	1167.7	3032.1	8127.2

1 mm. mercury = 2.778 pounds per square foot.

must take on an additional velocity as soon as the cold layer is placed upon it. Now, in the St. Louis tornado a cold mass of air was carried forward over the warm mass of stagnant air that had been lying over the city for several days, and in a few hours the temperatures fell about 18° F. = 10° C., the tornado occurring at the vertical junction of two masses of air at different temperatures, as in Table 30. It seems probable that *the warm air instead of mixing vertically with the cold sheet, slid out horizontally in all directions, that is radially from the point of greatest temperature contrast*, like the spokes of a wheel held horizontally above the head. If the velocities u, v, w in Tables 38, 39, and 40 are examined at the higher sections $az = 180°$ or $az = 170°$, it is seen that in this vortex the radial velocity above survives. Hence, we infer that the cause of this tornado was the horizontal flow of the warm air away from a center under the cold overflowing sheet, and that this radial action, whose purpose is to counteract the pressure change brought by the overflowing cold sheet, then propagated itself vertically downward in a dumb-bell-shaped vortex till it was cut off by the rough surface of the country and city at a section corresponding to an inflow of $i = 30°$, as found in the observations. This example of the effects of horizontal convection suggests the forces which are operating in the atmosphere during the mixture of warm or cold currents. Similar reasoning assigns the same cause for the generation of hurricanes, which are deep tornadoes of the dumb-bell shape (see fig. 8). The same action can be traced to about half the area of large ocean cyclones, but the inner rings show that the horizontal convection is due in part to the sheets of cold and warm air standing vertically, while in the land cyclone the

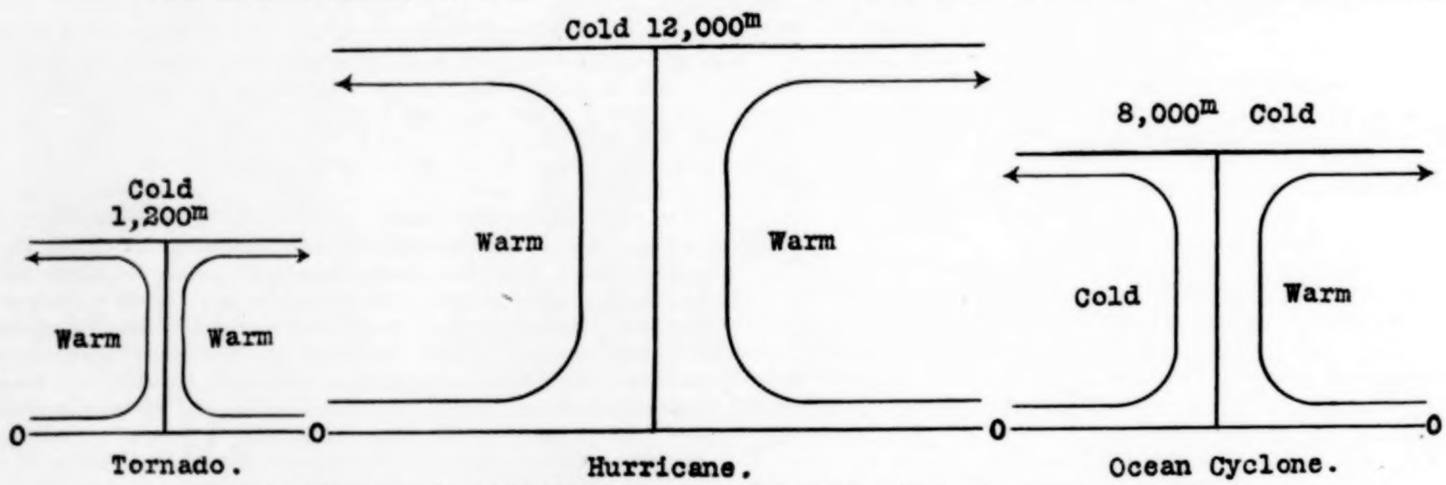


FIG. 8.—Diagram of the cold and warm masses of air in the tornado, hurricane, and ocean cyclone.

THE CAUSE OF THE FORMATION OF THE ST. LOUIS TORNADO.

In the last section of the first paper of this series on vortex motions it was shown that when two masses of air of different temperatures overlay one another, as a cold layer over a warm layer, there is a discontinuity in the pressure, caused by the different densities. But since in the air these discontinuities in the pressure can not persist under the forces of gravity, there is an immediate setting up of certain currents of motion which tend to destroy these pressure discontinuities and to restore a simple pressure gradient, such as is consistent with the prevailing temperatures. These temperatures and velocities are connected by the formula,

$$T_2(v_1^2 - v_0^2) = T_1(v_2^2 - v_0^2)$$

in which T_1 and v_1 are the temperature and average velocity, respectively, of the warm layer and T_2 and v_2 are the temperature and velocity of the cold layer and v_0 is the average velocity of the layer before disturbance.

Since the temperature of the cold layer, T_2, is connected with the motion of the warm layer, it follows that the warm layer vertical position of the plane separating the warm air from the cold air prevails and gives very impure vortices, tho their general typical features still survive.

The hurricane will be illustrated by the De Witte typhoon of August 1–3, 1901.

A TWO YEARS' STUDY OF SPRING FROSTS AT WILLIAMSTOWN, MASS.

By Prof. WILLIS I. MILHAM, Ph. D. Dated Williamstown, Mass., August 11, 1908.

INTRODUCTION.

Spring frosts have been quite extensively studied, chiefly on account of the damage caused by them which has excited popular interest in their prediction and in methods of protection against them. Among the more recent articles by those connected with the U. S. Weather Bureau may be mentioned:

Cline, I. M., "Irregularities in Frost and Temperature in Neighboring Localities." Third Convention of Weather Bureau Officials, Proceedings. Washington, D. C., 1904, p. 250.

Garriott, E. B., "Notes on Frost." Farmers Bulletin, No. 104.

Hammon, W. H., "Frost." W. B., No. 186.

McAdie, Alexander G., "Frost Fighting." W. B., No. 187.

It would be entirely impracticable here to attempt to mention all the literature on the subject. Abstracts of the original articles and references to them can, however, be found in the third volume of the Fortschritte der Physik for each year. They are given under the headings "Lufttemperatur," "Vorausbestimmung des Wetters," "Wetterschäden und Versuche zu ihrer Verhütung," and it would be necessary to cover about thirty years in order to be sure of finding all the articles of value.

The transition from the frosts of late winter or early spring to those of the late spring is unusually very well marked in Williamstown. It occurs normally a little after the middle of April. The wind will hold from the west or northwest for several days, accompanied very often by snow flurries, and the ground freezes solid at night. This marks the end of the winter régime and is the last unusually cold period. The wind then goes to the east or southeast, copious rain falls, the temperature rises markedly, vegetation makes rapid progress, and the air contains much more moisture. Those frosts which occur after this are of an entirely different nature and may be termed the spring frosts. These are the ones which do the damage to the growing vegetation.

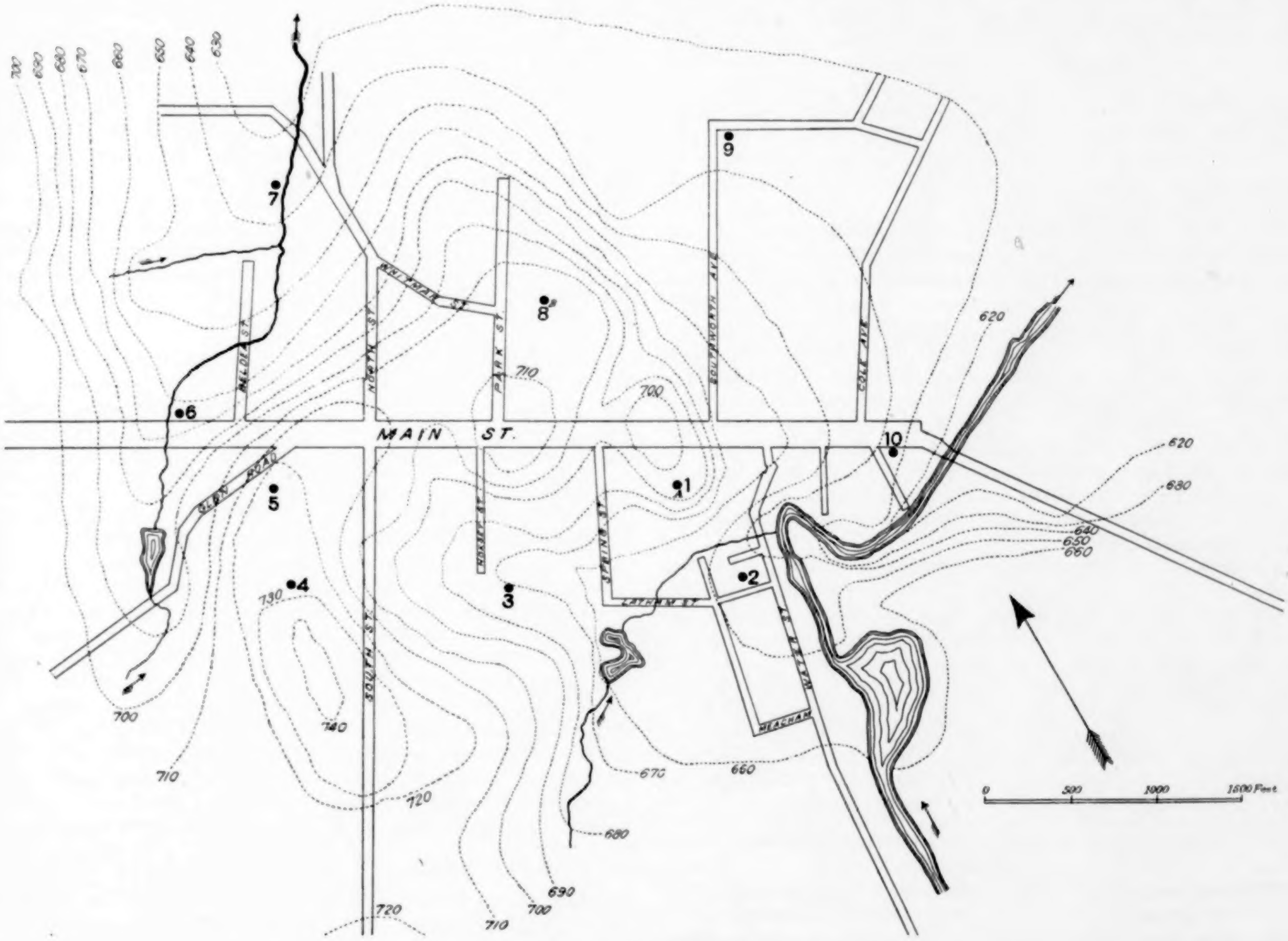


FIG. 1.—Contour map of Williamstown, Mass.

THE LINES OF INVESTIGATION.

If the consideration of the practical methods of frost prevention are here omitted, the various investigations of frost can be grouped into three classes:

1. The prediction of the probable minimum temperature from observations of weather conditions made during the previous afternoon. For a long time the idea prevailed that by following a simple formula the probable minimum temperature could be computed from the maximum and the dew-point, or the reading of the wet-bulb thermometer, of the afternoon before. This method has been tested, not alone for the cool days when a frost might be expected, but for all the days of the various months and at many stations and for a long time. The general conclusion has always been that the uncertainty is too great to make the method of any value in forecasting.

2. The variation in the severity of the frost at different places within a small area. Several times it has been observed that even within a small area the frost would be much more severe at one place than another, and the valleys and places of small elevation are usually found to be the coldest.

3. Variation in the severity of the frost with varying distance above the ground. The statement is sometimes made that the variation of temperature with distance above the ground is so marked in the lower 2 or 3 feet that the lower branches of shrubs may be frozen while the top escapes.

It is the purpose of this article to study, critically, the spring frosts at Williamstown during 1907 and 1908, in order

to come to as definite and exact conclusions along these three lines as can be formed.

A complete description of the village, together with an accurate topographic map[1], may be found in the MONTHLY WEATHER REVIEW for July, 1905, vol. XXXIII, p. 306. The three stations mentioned later in this article are practically identical with the stations numbered 1, 8, and 7 on the map, fig. 1. The village of Williamstown is particularly suited for this investigation because this limited area has been carefully investigated[2] for two years for variations in temperature over it under different conditions.

THE THERMOMETERS AND THEIR EXPOSURES.

Williams College is a cooperative station of the U. S. Weather Bureau and the shelter which contains the psychrometer and the registering thermometers, all of the regular Weather Bureau form, is located on the north side of the astronomical observatory, which is unheated. The shelter (*A* in fig. 1) is a sufficient distance from the building to allow proper ventilation and is located over sod. The instruments are 5½ feet above the ground. For the investigation of the frosts one station (1 in fig. 1) was chosen in the open about 15 feet northwest of the thermometer shelter. One reason for choosing such a location for one station was to be able to connect the series of readings with the indications of the thermometers in the shelter. Another station (7 in fig. 1) was located at the bottom of the valley, 66 feet lower than the first station, about 3,000 feet distant from, and almost due north of the shelter. The reason for choosing this location was the fact that in the investigation on variation of temperature[3] this station had always shown itself to be by far the coldest part of the village. A third station (8 in fig. 1), chosen largely as a check, was located about half-way between stations 1 and 7, and very nearly in a line with them. Its elevation is 3 feet greater than that of station 1 near the shelter *A*. Stations 8 and 7 were over sod, but some grading had been done at 1 so that there the grass was short and the ground partly bare. In the investigations of variation in temperature over a limited area, station 7 was always the coldest, while stations 1 and 8 were among the three warmest.

At each station was placed a frame for holding the thermometers. The thermometers used were self-registering minimum thermometers of the regular Weather Bureau type and two were placed at each station. They were mounted on unpainted pine boards about 18 inches long by 7 inches wide and exposed entirely in the open without a shelter of any kind. One was placed 5½ feet above the ground and the other one-half foot above the ground. This brought the lower thermometer just above the grass. The thermometers were identical and certainly accurate, but as a final precaution they were tested both before and after this investigation.

THE PREDICTION OF THE MIMIMUM TEMPERATURE FROM THE PRECEDING MAXIMUM.

The data from which the conclusions in this connection are drawn are given in Table 1. The first column contains the date which is always that of the day on which the maximum in question occurred. The minimum, of course, occurred on the morning of the following date. The second column contains the maximum temperature, and this always occurred between 2:30 and 4 p. m. The third, fourth, fifth, and sixth columns give the wind and sky observations at the time of the maximum. The four things given in order are wind velocity in miles per hour, wind direction, the proportion of the sky, in tenths, covered by clouds, the kind of clouds. In connection with the cloudiness 0 would indicate a cloudless sky and 10 would indicate a sky totally covered. The next two columns give the dew-point at the time of the maximum and at 8 p. m., respectively. The next column contains the following minimum temperature, and after this comes the wind and appearance of the sky at the time of the minimum. The temperatures in Table 1 were all taken from thermometers inside the shelter, and the dew-points were computed from a psychrometer also located inside the thermometer shelter. This table contains the observations on all those cool nights between the last of April, 1907, and the first of June, 1908, when frost seemed possible. It contains observations for all nights when the minimum temperature went to 40° or below, and for a few when it did not fall quite to 40°.

TABLE 1.—*Maximum and minimum temperatures on certain dates during the springs of 1907 and 1908 at Williamstown, Mass.*

Date.	Afternoon. Maximum.	Afternoon. Wind. Vel.	Afternoon. Wind. Dir.	Afternoon. Clouds. Amt.	Afternoon. Clouds. Kind.	Dew-point. Of max.	Dew-point. 8 p. m.	Following morning. Minimum.	Following morning. Wind. Vel.	Following morning. Wind. Dir.	Following morning. Clouds. Amt.	Following morning. Clouds. Kind.
1907.	°F.	mi. p. h.				°	°	°F.	mi. p. h.			
Apr. 27....	60	1	e.	0	....	38	32	32	½	e.	0	
May 1....	51	4	nw.	10	Cu.	37	34	33*	4	e.	9	Cu.
May 4....	50	7	s.	10	N.	....	....	30	2	nw.	2	Cu.
May 5....	54	2	nw.	0	....	29	34	38†	.....	.....	....	
May 11....	46	8	nw.	7	Cu.	....	29	27	2	nw.	0	‡
May 12....	54	4	nw.	0	....	26	32	42§	0	.....	0	
May 20....	53	10	nw.	4	Cu.	31	28	37	4	nw.	3	Cu.
May 21....	53	10	nw.	2	Cu.	31	30	39	4	nw.	5	Cu.
May 22...	55	2	nw.	6	Cu.	....	33	38	2	nw.	8	Cu.
May 23....	60	2	nw.	7	Cu.	....	42	37	2	nw.	1	Cu.
May 24....	64	2	nw.	0	....	....	36	33	1	nw.	0	
May 28....	50	15	nw.	9	Cu.	33	27	37	6	nw.	0	
1908.												
Apr. 29....	58	3	sw.	5	Cu.	43	43	40	1	nw.	10	S.‖
May 1....	46	8	nw.	10	S.-cu.	30	33	39	1	nw.	5	Cu.
May 2....	56	2	s.	9	Cu.	....	44	35	20	w.	10	N.¶
May 3....	49	12	nw.	9	Cu.	41	37	35	1	nw.	0	
May 4....	57	7	nw.	3	Cu.	37	40	32	½	nw.	0	
May 5....	60	2	nw.	0	....	39	41	46	½	nw.	0	
May 9....	51	6	nw.	10	N.	....	37	39	8	nw.	9	Cu.
May 10 ...	51	6	nw.	9	Cu.	35	37	42	3	nw.	0	
May 14....	54	5	e.	10	N.	...	47	40	4	e.	9	Ci.-Cu.

* Minimum at 3:30 a. m. † Minimum at 12:30 a. m.; rained later. ‡ Snow flurries during p. m. § Minimum at 12:10 a. m. ‖ Night cloudless. ¶ Snow during night.

When this investigation was begun the author held the preconceived idea that even if the minimum temperature could not be computed with certainty from the preceding maximum, yet the characteristics of those cool spring nights when a frost seemed probable would be so nearly the same that here such a computation would be a possibility. It would seem that if the dew-point were not past, the drop in temperature ought to be very nearly a constant on different nights. And if the dew-point were past it would seem that there would be a certain fractional lessening of the further amount of drop on account of the latent heat given out by the condensation of moisture. The drop in temperature from the maximum to the following minimum could thus be exprest by a formula such as:

$$\text{Drop} = t_m - t_d + A\{B - (t_m - t_d)\}$$

where t_m = maximum, t_d = dew-point, A and B are constants. This would of course hold only for those cases where $t_m - t_d$ is less than B. For all other cases the formula would be simply

$$\text{Drop} = B.$$

The constants A and B could be determined from a series of observations since the drop, t_m and t_d are quantities which can be observed.

As soon as observations began to be made it was seen at once that the dew-points were extremely low and that the minimum temperatures in most cases were above the dew-points, or at most only a few degrees below. That means that on these cool days when a frost seems probable, the air is so dry that the dew-point plays practically no part in determining the minimum temperature, since there seems to be

[1] The map is reprinted here for the convenience of the reader.
[2] See the Monthly Weather Review for July, 1905, XXXIII, p. 305, and for August, 1906, XXXIV, p. 370.
[3] See Monthly Weather Review, *loc. cit.*

no retardation of cooling due to the liberation of latent heat after the temperature has past the dew-point. It is thus to be expected that the drop in temperature would be a constant. Now, the average drop for 1907 and 1908, neglecting those nights when the minimum came before sunrise, is 16.9°, and the greatest and least values are 31° and 7°. It will be seen at once that the amount of the drop is very far from a constant. One is thus forced to the following conclusions:

1. The cool nights of spring, when a frost might be expected, are very dry and the dew-point lies so low that it plays practically no part in determining the minimum temperature.

2. The amount of the drop from the maximum to the following minimum is very far from a constant, even if the characteristics of these nights seem very nearly the same. In each case, in estimating the probable drop, one must take into account the probable amount of cloud, the probable wind velocity, the possibility of a change in wind direction, and possibly other things.

It was intended to extend this investigation over the past ten years, but as soon as the above conclusions became certain it seemed unnecessary to publish the observations for more than the two years. The previous records were, however, carefully gone over to be sure that 1907 and 1908 were not unique years and that they bore out the above conclusions. It should be mentioned in passing, that no lack of ventilation on the part of the psychrometer can account for the low dew-points. If the instrument had been poorly ventilated, the wet-bulb reading would have been too high and the computed dew-point would be too high rather than too low.

VARIATION IN TEMPERATURE DIFFERENCES OVER A LIMITED AREA.

The conclusions as to areal variations in the severity of the frosts are based upon the observations given in Table 2. The first column contains the date of the observation. In this column u refers to the upper thermometer, placed $5\frac{1}{2}$ feet above the sod, and l to the lower thermometer, placed $\frac{1}{2}$ foot above the sod. The next four columns contain the temperatures at 8 p. m., in the shelter A and at stations 1, 8, and 7. Succeeding columns give the wind and sky at 8 p. m., while the last four columns contain the minimum temperatures recorded in the shelter A and at stations 1, 8, and 7.

TABLE 2.—*Observations at 8 p. m., and the following minimum temperatures at three stations and two elevations in Williamstown, Mass.*

Date.	Temperatures at 8 p. m.				Wind and clouds.				Minimum.			
	A	1	8	7	Velocity.	Dir.	Amt.	Kind.	A	1	8	7
1907.	°F	°F	°F	°F	mi. p. h.				°F	°F	°F	°F
April 27 ... u	51	50	48	42	1	e.			32	...	30	27
April 27 ... l	...	48	45	38			0		...	30	27	23
May 1 ... u	46	43	40	35	1	nw.			33	29	28	25
May 1 ... l	...	42	36	30			0		...	28	25	21
May 4 ... u	34	34	34	34	15	nw.			30	...	...	...
May 4 ... l	...	34	34	34			8	Cu.	...	...	...	...
May 5 ... u	45	43	40	37	0				38	36	32	31
May 5 ... l	...	42	37	34			10	Ci.	...	34	32	27
May 11 ... u	37	37	37	37	6	nw.			27	25	...	18
May 11 ... l	...	37	37	37			6	Cu.	...	24	..	15
May 12 ... u	44	43	41	36	1	nw.			42	41	39	33
May 12 ... l	...	43	38	31			0		...	40	36	31
May 20 ... u	45	44	42	42	7	nw.			37	35	34	34
May 20 ... l	...	43	40	40			4	Cu.	...	35	32	31
May 21 ... u	42	42	40	42	5	nw.			39	38	36	36
May 21 ... l	...	42	38	39			1	Cu.	...	38	34	33
May 22 ... u	49	...	...	...	2	nw.			38	...	...	31
May 22 ... l	...	...	...	...			6	Cu.	...	...	...	28
May 23 ... u	52	...	...	...	2	nw.			37	...	...	...
May 23 ... l	...	...	...	...			6	Cu.	...	...	...	...
May 24 ... u	53	...	...	...	2	nw.			33	31	...	25
May 24 ... l	...	...	...	...			0		...	30	...	20
May 28 ... u	44	43	42	...	12	nw.			37	36	34	31
May 28 ... l	...	42	40	...			0		...	36	32	31
1908.												
April 29 ... u	50	49	47	40	2	w.			40	38	37	35
April 29 ... l	...	49	47	40			10	S.	...	38	36	34
May 1 ... u	42	40	39	40	1	nw.			39	37	35	31
May 1 ... l	...	39	37	38			2	Cu.	...	36	32	28
May 2 ... u	48	...	...	...	1	s.			35	...	...	...
May 2 ... l	...	...	...	...			10	N.	...	...	...	...
May 3 ... u	45	44	44	...	2	nw.			35	33	31	31
May 3 ... l	...	44	44	...			7	Cu.	...	33	30	27
May 4 ... u	46	45	46	39	¼	nw.			32	30	28	28
May 4 ... l	...	45	46	36			0		...	30	27	24
May 5 ... u	51	50	48	...	1	nw.			46	45	43	40
May 5 ... l	...	49	45	...				haze.	...	44	39	35
May 9 ... u	44	42	42	42	6	nw.			39	39	38	38
May 9 ... l	...	42	41	42			6	Cu.	...	39	37	38
May 10 ... u	46	45	44	44	6	nw.			42	40	38	36
May 10 ... l	...	45	44	44			4	Cu.	...	40	36	34
May 14 ... u	49	47	46	43	1	nw.			40	39	39	36
May 14 ... l	...	47	45	40			0		...	39	37	34

u Observations of thermometer $5\frac{1}{2}$ feet above ground. l Observations of thermometer $\frac{1}{2}$ foot above ground.

The chief results of these observations are summarized in Table 3. This table contains the average and the largest differences between the shelter A and station 1, station 1 and station 8, and station 1 and station 7, for both the upper and lower thermometers at the hours recorded.

It will be noticed the indications of identical thermometers in the thermometer shelter and at station 1 in the open only 15 feet away, and at the same height above the ground, differ by 1.2° F. at 8 p. m., on the average, and by an average of 1.6° at the time of the minimum. This is but a confirmation of the well-known fact that a thermometer in the open radiates its heat to the sky, and therefore indicates a temperature below the real air temperature. It is probably, however, an approximation to the temperature which vegetation would have in the same location, as this also radiates its heat. This difference is worked out on the assumption that the shelter gives the real air temperature. On still clear nights, however, it is a question if a thermometer placed in a shelter without artificial ventilation, does not indicate temperatures slightly above the true temperature of the outside surrounding air.

TABLE 3.—*Summary of differences in temperature.*

Stations.	Height of thermometers.	At 8 p. m.		At time of minimum temperature.	
		Average.	Largest value.	Average.	Largest value.
	Feet.	°	°	°	°
Shelter A and 1	5.5	1.2	3	1.6	4
1 and 8	5.5	1.2	3	1.8	4
	0.5	2.3	6	3.2	5
1 and 7	5.5	3.6	9	4.0	8
	0.5	5.4	12	6.4	10

The average difference for both the upper and lower thermometers between station 1 and station 8, and station 1 and station 7, is greater at the time of the minimum than at 8 p. m. Columns 3 and 5 of Table 3 present these contrasting values. This is what would naturally be expected, for the wind velocity averages greater at 8 p. m. than at the time of the minimum, and the variation over a limited area depends to a marked extent on wind velocity. The average difference is also greater for the lower thermometers than for the upper. This is also to be expected as the air near the ground would be held quiet by friction and replaced much more slowly than at a small height above it. The magnitude of the difference, particularly in the case of the lower thermometer, and the contrast between station 1 and station 7 are worthy of note. The average difference amounted to as much as 6.4° F. and the largest value was 10° F.

VARIATION IN TEMPERATURE DIFFERENCES WITH DISTANCE ABOVE THE GROUND.

The chief results of the study of the variations in temperature differences with distance above the ground are summarized in Table 4. The average value and the largest value of the difference between the indications of the upper and lower thermometers, at 8 p. m. and at the time of the minimum, are here given for the three stations.

Table 4.—*Summary of observations, showing temperature difference with height.*

	At 8 p. m.			At time of minimum temperature.		
Stations	1	8	7	1	8	7
Upper-lower:	°	°	°	°	°	°
Average difference	0.5	1.5	2.1	0.5	2.0	2.9
Largest difference	2	4	5	2	4	5

Three things are to be noticed: the smallness of the difference; the fact that the difference is greater at the time of the minimum temperature; and the fact that it is greatest at the coldest station. The largest average difference is only 2.9° and the actually largest value is only 5°. The difference is ordinarily supposed to be much larger than this. It is to be expected that the difference would be greater at the time of the minimum for the wind velocity is less. It is not altogether apparent why it should be greatest at the coldest station unless, as a valley station, it is more sheltered and the wind velocity is thus less.

OTHER RESULTS.

There are certain well-known and almost self-evident facts in connection with frosts, which need only be mentioned in passing. A still clear night is almost essential for a large drop in temperature and a consequent frost. Wind mixes the air and thus prevents the lower layer from cooling excessively, while a clear sky is essential for that free radiation from the ground which is one of the chief causes of the cooling. The wind was almost without exception northwest when a frost occurred; and frosts were found to occur on the first or second night following the passage of a "low," when the weather of the area studied was in transition to the control of an approaching area of high pressure.

It will be noticed that the dew-point at 8 p. m. was sometimes higher and sometimes lower than it was at the time of the maximum temperature in the afternoon. Either state of things can be readily explained. If there were no importation of drier air by the wind, the continual evaporation of water vapor from the ground and vegetation ought to add moisture to the air during the afternoon and thus raise the dew-point. The importation of drier air, however, is often sufficient to counteract the effects of this process and cause a drop in the dew-point.

Two processes operate to produce the cooling which may result in a frost. These are first, the importation of cooler air, and second, the radiation of heat from the ground and the cooling of the air next to it by conduction. It might seem that the cool nights during which frosts seem probable, could be divided into two groups depending upon whether the importation of cold air or radiation from the ground was playing the larger part in producing the cooling. This is, however, hardly practicable, because both processes are nearly always operative. On some occasions a strong northwest wind will import cool, dry air, thus holding down the maximum temperature during the day and causing a low dew-point. If the wind dies down during the night and the sky becomes clear, it takes but little radiation to cause a frost. On other occasions there seems to be but little importation of cool, dry air, the sky is very clear and there is almost no wind. Radiation is excessive and the resulting large drops in temperature may cause a frost. While both processes are usually active, it is generally easy to see which predominates.

SUMMARY.

The chief results and generalizations brought out in this study are summarized below. Of course these apply to Williamstown only, but the conclusions would probably be very similar for the whole of New England, and a similar set of data can be worked out for any place.

The so-called spring frosts may be expected from the last of April until the first of June and occur on still, clear nights, with the wind almost invariably from the northwest. They are likely to come on the first or second night following the passage of a low and the transition of the weather control to an area of high pressure. This facilitates both the importation of colder air and radiation, the two processes which cause the low temperatures required. The air is so dry and the dew-point lies so low that it plays no part whatever in determining the amount of the drop from the maximum to the following minimum. The drop is, however, far from a constant, and must be estimated for each individual case, taking into account the probable characteristics of the afternoon and night.

If, after the probable minimum temperature in the thermometer shelter has been estimated, it is desired to determine what the probable temperature of low-growing vegetation in the coldest part of the limited area will be, three things must be taken into account. First, that plant temperatures go below the real air temperatures, because the plants are in the open without such a hindrance to radiation as is the shelter about a thermometer; second, that vegetation is located near the ground and not at the height of the instruments in the shelter; third, that the variation in temperature over a limited area may amount to several degrees. Were this computation carried out with the average values for Williamstown, about 2° would be allowed for exposure in the open, 3° for height, and 6° for variation between the shelter and the coldest part of the area. Thus the temperature of vegetation in the open, near the ground, in the coldest part of the village may be expected to average 11° lower than the estimated minimum in the shelter as it is now located.

GOVERNMENT METEOROLOGICAL WORK IN BRAZIL.

By Prof. Robert De C. Ward, Harvard University. Dated, Curityba, State of Parana, Brazil, August 6, 1908.

The following notes were made during a trip to Brazil in July and August, 1908, the object of which was to gather information, at first-hand, covering the climate, products, and development of that country. They are to be continued in the Monthly Weather Review for September, 1908, where will also appear a map showing the location of the stations.

METEOROLOGY AT THE NATIONAL OBSERVATORY.

The National Astronomical Observatory at Rio de Janeiro, Brazil, is situated on the Morro do Castello, one of the hills overlooking the city, in a very densely populated section close to the harbor. The building was once part of an old Jesuit monastery, and is today extremely picturesque and interesting, with its *patio* filled with trees and shrubs; its rambling stone stair-cases and passage-ways; its quaint architecture, and the crowded population which surrounds it. The oldest church in Brazil, built in 1567, forms a part of the pile of buildings in which the observatory is now placed. Rumor says there are vast stores of hidden treasure in the hill, beneath the old monastery, and excavations have been made from time to time, in order to discover these riches, but so far without success.

The offices of the observatory are in the upper story of the building, and the instruments are placed at various points on the roof. The thermometers (wet and dry bulb) and thermographs are well exposed at the top of one of the principal towers. The shelter has a double roof, double louvered sides, and is large enough to walk about in.

In the main office, directly beneath this shelter, are placed the standard mercurial barometer (Fuess), and the self-recording instruments, which are of the usual Richard Frères patterns. There is also a new and quite inexpensive English self-recording anemometer, constructed on the pressure-tube plan. This instrument has not yet proved altogether satisfactory.

Outside, on the roof, three or four self-recording raingages are rather poorly exposed, being protected to some extent by higher portions of the building. The actual rainfall is taken to be the mean of the amounts registered by these gages. A Campbell-Stokes sunshine recorder is exposed at another point on the roof, and anemometers of several patterns are placed at the top of an open iron-work tower, rising well above the highest part of the roof.

The former Director, Dr. Luiz Cruls, died a few months ago, and the observatory is now in charge of Dr. H. Morize, formerly Doctor Cruls' assistant. The work is reported to be much hampered by lack of funds, and is at present chiefly meteorological. The astronomical work seems to be confined to the time-service, and to the regulation of chronometers belonging to the navy. A Bosch-Omori seismograph is installed at the observatory, and is giving satisfactory results. A new Wiechert seismograph, now at the grounds of the National Exposition, is to be placed on the observatory hill as soon as the exposition closes. It is Doctor Morize's intention to begin observations on atmospheric electricity at an early date, and he is now in correspondence with Dr. Leonard Weber, of Germany with reference to inaugurating a series of photometric observations at Rio de Janeiro. The meteorological observations in charge of the director of the observatory are independent of those made under the direction of the Navy, and of the Telegraph Department, referred to below, although the observatory publications frequently include results obtained at stations not under its own jurisdiction.

The publications of the Observatory of Rio de Janeiro are as follows:

1. Revista do Observatorio. Publicação mensal do Imperial Observatorio do Rio de Janeiro (1886–1891). This Revista, which was the continuation of the Boletim astronomico e meteorologico, published from 1881 to 1884, contained at first the monthly means for Rio de Janeiro, together with some brief and rather unreliable summaries for other stations. From August, 1889, to July, 1890, the Revista included the observations made at Greenwich noon at three stations.

(2) Boletim Mensal do Observatorio do Rio de Janeiro. The publication of this Boletim began in 1900. It contains meteorological and magnetic data more carefully discust, and set forth in better form than in the old Revista.

(3) Anuario publicado pelo Observatorio do Rio de Janeiro. The Anuario has appeared annually since 1885, when it began. It is the best known publication issued by the observatory, and contains, in addition to the astronomical tables for the year, occasional short meteorological discussions, and meteorological observations from different parts of Brazil as well as those made at the observatory. The latest volume of the Anuario (1908, XXIV), is a small octavo publication of 353 pages. It includes a large number of useful astronomical, physical, and meteorological tables. In the index, reference is made to page 354 for a "summary of meteorological observations made at the Rio Observatory and in some of the provinces [states] during the year 1906," but this summary was for some reason omitted entirely, the last page in the volume being 353.

As part of the work of the Observatory for Meteorology may be noted the publication, by the late director, Doctor Cruls, of a report entitled, Le climat de Rio de Janeiro d'après les observations météorologiques faites pendant la période de 1851–1890 (Rio de Janeiro, 1891, in French and Portuguese). The matter herein contained was first published in the Revista do Observatorio, and the report was the first attempt to present a discussion of the climatology of Brazil. Altho the data at hand were insufficient to make possible anything like a complete treatment of the subject, the work presents many important generalizations. Mean annual temperatures and rainfalls, but no monthly means, are given. Doctor Morize has also published a report, in Portuguese and in French, on the climatology of Brazil (1891).

METEOROLOGY IN THE BRAZILIAN NAVY.

The most important meteorological work now being done by the Brazilian Government is that under the charge of the Navy Department.[1] The publications of this department include:

(1) Boletim dos Observações Meteorológicas a 0^h de Greenwich ($9^h\ 07^m$ a. m. do Rio) e dos Rezultádos magnéticos, monthly.

(2) Boletim Semestral dos Rezultádos obtidos na Estação Central no Morro do Santa Antonio (Rio de Janeiro) e nos Estações meteorológicas e pluviométricas, semiannually.

(3) Serviço Meteorológico Nacional, Boletim telegráfico diario, which is a daily weather map.

This department has also published Taboas meteorológicas, Rio de Janeiro, 1900, p. 89, large octavo. This set of tables is reprinted from a large volume of instructions entitled Instrucções Meteorològicas, Rio de Janeiro, 1900, p. 98, large octavo. Practically these instructions constitute a short textbook of meteorology, and have doubtless been very useful in stimulating the interest of the observers, as well as in giving them information of which they were not in possession. Unfortunately, however, the matter included in the volume is out of date in a good many cases, and somewhat misleading, as, e. g., in the case of Faye's cyclonic theory. The volume is divided into three parts, as follows: I. Meteorology and its subdivisions. II. Meteorological observations. III. Reduction tables. The longest section deals with atmospheric electricity and magnetism, as was perhaps natural in a work intended chiefly for the use of the navy. There is also a selection of weather proverbs, compiled from the list published some years ago by the U. S. Signal Service, most of which must be singularly out of place in Brazil.

The central station of the meteorological service of the Brazilian Navy is on the Morro do Santo Antonio, one of the hills of Rio de Janeiro, at an altitude of 64.5 meters above sea level. The instrumental equipment is as follows: Mercurial barometer, Kew pattern (Negretti and Zambra), reading in inches and in millimeters; a psychrometer; a Piche evaporometer; maximum and minimum thermometers; a rain-gage (Negretti and Zambra), having a diameter of 126 millimeters and standing 1.70 meters above the surface of the ground; a Redier mercurial barograph; a Richard thermograph; Capello anemographs; Fleuriais' anemometer, a modification of the Robinson pattern, recording the velocity in kilometers per hour by electrical contact whenever the observer closes the circuit; a Campbell-Stokes sunshine recorder. In addition to the central station at Rio de Janeiro, the Navy Department has[2] one first-order station (Curityba), which is really under the control of the Telegraph Department (see below); 21 second-order stations; 4 third-order stations, and 5 rainfall stations, making 31 in all. Of these about one-half are in charge of persons connected with the navy, while others are in charge of harbor commissions, telegraph officials, boards of health, directors of public works, etc. In location the stations range from Para (lat. 1° 28′ S., long. 48° 27′ W.) to Barra do Rio Grande do Sul (lat. 32° 09′ S., long. 52° 03′ W.) and from Manaos (lat. 3° 08′ S., long. 59° 59′ W.) to Parahiba (lat. 7° 06′ S., long. 34° 51′ W.).

The latest monthly Boletim (1896–1907 have been published) contains the observations made at Greenwich noon ($9^h\ 07^m$ a. m., Rio time) at the 31 stations above referred to, most of these

[1] Ministerio de Marinha. Repartição da Carta Maritima. Secção de Meteorologia.

[2] These figures are taken from the monthly Boletim for March, 1907 (Anno XII, No. 3, published in April, 1908), the latest number available during the writer's visit in Rio. There may have been some changes in the number and in the classification of the stations since then.

stations being directly on the coast. The record includes pressure, temperature (dry bulb and difference between dry and wet-bulb readings), relative humidity, vapor tension, cloudiness (kind and amount), general state of the weather, wind (direction and velocity on Beaufort scale), and remarks. The monthly means are also given. At the rainfall stations the daily observations are limited to wind direction and velocity, amount of cloud, general state of the weather, and precipitation. The Boletim also includes the results of magnetic observations made at the central station in Rio de Janeiro, and a map showing the magnetic variation for 1904 in different parts of Brazil, as determined by the first Brazilian magnetic survey.

The Boletim Semestral, of which sixteen numbers have been issued, was first published in 1898, and has grown from a small pamphlet to an octavo volume of somewhat over 1,000 pages. The last issue is No. 16, October, 1904, to March, 1905, dated Rio de Janeiro, 1907. This contains in full, the results of the observations at the several stations above referred to. The service is apparently growing in a healthy way. An inspection of the various stations, of which the details are given in the last Boletim Semestral, showed on the whole a satisfactory condition. It is hoped soon to be able to equip the coast steamers of the Brazilian Lloyd with meteorological instruments. One great difficulty now encountered is the delay of all publications which are printed at the Government Printing Office, and it is the intention of the Navy Department to establish, at the earliest possible moment, a printing plant of its own. The observations at the central station (Morro do Santo Antonio) in Rio de Janeiro are given hourly, the values for the night hours being taken from self-recording instruments, and include pressure, temperature, relative humidity, vapor tension, kind and amount of cloud (6 a. m.–11 p. m.), general weather conditions, character of precipitation (if any), optical and other phenomena, direction and velocity of the wind (Beaufort scale), frequency of different wind directions and velocities by hours, and a summary for each day, giving maximum and minimum temperatures, evaporation, and amount of rainfall. Monthly, six-months, and annual means are also given. For the second-order stations the observations are given in full for 9 a. m., noon, and 9 p. m., and are summarized for each month, for six months, and for the year. In the last number of the Boletim Semestral the number of stations given,[3] excluding Rio de Janeiro, is 8 second-order (three observations a day), 3 third-order stations (noon observation only), and 7 rainfall stations. The magnetic observations made at the central station are also included.

[*To be continued.*]

FURTHER OBSERVATIONS OF HALOS AND CORONAS.[1]

By M. E. T. GHEURY. Dated Eltham, England, July 10, 1908.

On examining the results of the complete year of observations of halos, etc., I was struck by the fact that it shows that, while the failures are evenly distributed for all the phenomena except the solar halos, the latter exhibit very few failures and and seem a very good guide. Other particularities develop on examination. I therefore submit the observations for the last part of the year 1907 to complete the work already published in the MONTHLY WEATHER REVIEW.[1] I do not think the further publication of other years' observations would be of much avail altho one year's complete record of halos, coronas, and rainfalls in England may prove interesting.

[3] At the end of 1904.

[1] Previous papers in this series appeared in the Monthly Weather Review, May, 1907, XXXV, p. 213; and December, 1907, XXXV, p. 579. The table accompanying closely follows in arrangement, abbreviations, etc., the tables of the previous papers.

TABLE 1.—*Observations of halos, coronas, etc., at Eltham, England, July-December, 1907.*

No.	Date and time of day, 1907.	Nature of phenomenon.	Previous minimum.	Previous maximum.	Mean barometer for preceding 24 hours.	Following minimum.	Following maximum.	Mean barometer for following 24 hours.	Weather at time of observation.	Weather during following 24 hours.	Description of phenomenon and general remarks.
1	2	3	4	5	6	7	8	9	10	11	12
			°C	°C	*Inches.*	°C	°C	*Inches.*			
53	July 1, 7:30 p. m.	Annulus, S.	9.2	15.7	29.69, rising from 29.64 to 29.74.	12.1	17.2	29.74, steady	Fine, cloudy, light wind.	Cloudy, rain	With undefined edge, extending to 1 d.
54	July 2, 8 p. m.	Annulus, S.	12.1	17.2	29.74, steady	8.2	17.5	29.60, falling from 29.73 to 29.45.	Fine, cloudy, windy.	Wet all day.	With undefined edge, extendi g to 1 d.
55	July 13, 10:30 a. m.	Corona, S.	10.3	20.2	30.08, falling from 30.15 to 30.04.	15.9	23.5	30.04, steady	Fine, cirro-cumuli veil.	Overcast, rain	Seen with biconvex lens; reddish, from 3 to 4 d.
56	July 13, 10:45 a. m.	Halo, S.	10.3	20.2	30.08, falling from 30.15 to 30.04.	15.9	23.5	30.04, steady	Fine, overcast	Overcast, rain	Halo of 22°, reddish.
57	July 20, 7 p. m.	Annulus, S.	13.5	20.2	29.94, variable	13.6	21.9	29.91, falling from 29.94 to 29.83.	Fine, cloudy, still	Overcast, hazy, very gloomy, distant thunder.	With undefined edge, extending to ½ d.
58	July 21, 6 p. m.	Annulus, S.	13.6	21.9	29.91, falling from 29.94 to 29.83.	15.2	21.0	29.78, falling from 29.83 to 29.72.	Overcast, very gloomy.	Pouring rain	With undefined edge, extending to 1 d.
59	July 25, 2 p. m.	Corona, S.	9.9	.....	.....	.....	.....	.....	Fine, cloudy, still	Rapidly overcast, pouring rain.	Seen with biconvex lens; reddish, from 4 to 5 d.
60	July 26, 10 a. m.	Corona, S.	.....	.....	.....	.....	.....	.....	Fine, cloudy, light wind.	Overcast, rising wind, showery.	Seen with biconvex lens; reddish, from 2½ to 3½ d.
61	July 27, 3:30 p. m.	Corona, S.	.....	.....	.....	.....	.....	.....	Fine, cloudy, light wind.	Cloudy, windy, overcast, rain.	Seen with biconvex lens; orange and red, from 2 to 3 d.
62	July 29, 3 p. m.	Halo, S.	.....	.....	.....	.....	.....	.....	Fine, windy, cirri veil.	Overcast, strong wind.	Halo of 22°, inner edge orange, outer edge bluish; lasted 2 hours.
63	July 31, 7 p. m.	Annulus, S.	.....	.....	.....	.....	.....	.....	Fine, cloudy, light wind.	Fine, very pure; cloudy, overcast, strong wind.	With undefined edge, intermittent, variable, extending to a distance from the limb varying from ½ to 1½ d.
64	Aug. 1, 10:30 a. m.	Halo, S.	.....	.....	.....	.....	.....	.....	Fine, cloudy, light wind.	Cloudy, overcast, strong wind.	Halo of 22°, inner edge reddish, outer edge bluish.
65	Aug. 2, 3 p. m.	Corona, S.	.....	.....	.....	.....	.....	.....	Fine, sun behind a very bright veil of pink cumuli, light wind.	Overcast, rain, and strong wind.	Seen with biconvex lens; reddish, from 1½ to 2½ d.
66	Aug. 4, 12:30 p. m.	Halo, S.	.....	.....	.....	.....	.....	.....	Veiled sky, strong wind.	Overcast, strong wind, some rain.	Halo of 22°, pale orange.
67	Aug. 4, 5 p. m.	Rainbow, S.	.....	.....	.....	.....	.....	.....	.....	.....	Single, faint.
68	Aug. 16, 10 a. m.	Halo, S.	.....	.....	.....	.....	.....	.....	Fine, cirri veil	Overcast, rain, gale.	Halo of 22°, inner edge orange, outer edge bluish.
69	Aug. 18, 8 p. m.	Corona, M.	.....	.....	.....	.....	.....	.....	Fine, cloudy, light wind.	Strong wind, heavy squall of rain.	Reddish, from 2 to 3 d.
70	Aug. 18, 10 p. m.	Annulus, M.	.....	.....	.....	.....	.....	.....	Fine, light wind, sky apparently very pure.	Strong wind, heavy squall of rain.	With well-defined edge, from limb to 5′ distance round the gibbous moon, following exactly the shape of the illuminated portion; greenish, with a very narrow reddish edge 1′ in width; outside, a pale orange annulus with undefined edge, extending to ½ d.

TABLE 1.—*Observations of halos, coronas, etc., at Eltham, England, July-December, 1907*—Continued.

No.	Date and time of day, 1907.	Nature of phenomenon.	Previous minimum.	Previous maximum.	Mean barometer for preceding 24 hours.	Following minimum.	Following maximum.	Mean barometer for following 24 hours.	Weather at time of observation.	Weather during following 24 hours.	Description of phenomenon and general remarks.
1	2	3	4 °C	5 °C	6 Inches.	7 °C	8 °C	9 Inches.	10	11	12
71	Aug. 25, 10:30 p. m.	Annulus, M.							Very fine, sky with a very light veil.	Overcast; fine and cloudy, light wind.	With undefined edge; very wide, extending to 2½ d. Outer part (width ½ d.) reddish. Seems a small corona the inside of which would be bright up to the moon's limb. Outside, a very pale and indistinct ring, touching it and extending to 5 d.
72	Aug. 26, 4 p. m.	Corona, S.							Fine and cloudy, light wind.	Overcast; fine and still.	From 2 to 3 d., reddish edge, inside very bright.
73	Aug. 27, 6:30 p. m.	Annulus, S.							Cloudy, fine, still ...	Cloudy, fine, still ...	With undefined edge, extending to 1 d.
74	Aug. 30, 5 p. m.	Halo, S.							Cloudy, fine, still ...	Overcast, fine, light wind.	Halo of 22°, inner edge reddish, outer edge bluish; lasted 1 hour.
75	Aug. 30, 6:15 p. m.	Corona, S.							Cloudy, fine, still ...	Overcast, fine, light wind.	With undefined edge, extending to 1 d.
76	Aug. 31, 4 p. m.	Halo, S.							Cloudy, fine, light wind.	Strong wind, cloudy, fine (storm, pouring rain).	Halo of 22°, inner part yellow, outer edge bluish.
77	Sept. 1, 12:30 p. m.	Halo, S.							Strong wind, fine, cloudy.	Overcast, strong wind, rain (storm, pouring rain).	Halo of 22°, inner part yellow, outer edge bluish; lasted 2 hours.
78	Sept. 8, 5:45 p. m.	Annulus, S.	13.6	21.9	30.17, rising from 30.07 to 30.23.	12.1	19.8	30.23, variable....	Fine and warm, cloudy, light wind.	Overcast, fine and warm.	With undefined edge, extending to 1 d., orange.
79	Sept. 15, 6 p. m.	Annulus, S.	8.4	17.4	30.10, rising from 29.98 to 30.18.	8.6	20.9	30.18, variable....	Fine, cloudy, still...	Overcast, light wind.	With undefined edge, extending to 1 d., red. (Sun very low.)
80	Sept. 25, 10 a. m.	Halo, S.	10.7	19.9	29.70, falling from 29.82 to 29.58.	16.0	24.9	29.55, falling from 29.58 to 29.53.	Fine, very hot, still.	Cloudy, rising wind, overcast, rain.	Halo of 22°, faint, milky (after three weeks of settled, splendid weather without any halos, coronas, or annuli).
81	Sept. 25, 10 p. m.	Annulus, M.	10.7	24.9	29.60, falling from 29.70 to 29.56.	16.0	22.0	29.53, falling from 29.57 to 29.51.	Cloudy, light wind..	Overcast, rain......	With undefined edge, extending to ½ d.
82	Sept. 27, 1 p. m.	Halo, S.	14.6	22.0	29.51, steady......	14.3	22.1	29.60, rising from 29.52 to 29.64.	Cloudy, rising wind.	Cloudy, strong wind.	Halo of 22°, milky.
83	Oct. 11, 6 p. m.	Annulus, M.	11.3	16.7	29.67, variable....	10.0	16.9	29.82, variable....	Cloudy, a little wind.	Overcast, strong wind, pouring rain.	Oval shaped around the crescent; with undefined edge, over all dimensions 1½ and 1 d.
84	Oct. 15, 10 p. m.	Corona, M.	9.6	13.2	29.11, rising from 29.04 to 29.25.	6.0	11.5	29.10, falling from 29.25 to 28.94.	Cloudy, a little wind.	Overcast, pouring rain.	From 3 to 4½ d., reddish.
85	Oct. 16, 10 a. m.	Annulus, S.	6.0	13.2	29.17, variable....	10.1	11.5	28.99, variable....	Overcast, sun showing faintly.	Overcast, pouring rain.	With undefined edge, extending to ¼ d.
86	Oct. 17, 10 p. m.	Corona, M.	10.1	12.0	28.97, rising from 28.94 to 29.00.	7.7	13.3	29.10, variable....	Cloudy, still........	Overcast, strong wind, rain.	From 3½ to 5 d., reddish.
87	Oct. 18, 10 p. m.	Corona, M.	7.7	13.3	29.10, variable....	11.3	16.3	29.39, rising from 29.18 to 29.55.	Cloudy, gale........	Overcast, gale, pouring rain.	Reddish, of variable diameter.
88	Oct. 20, 8:30 p. m.	Double corona, M.	11.1	15.8	29.50, variable....	10.7	16.9	29.69, rising from 29.63 to 29.74.	Cloudy, warm, fine, fresh wind.	Fine, cloudy, still...	Double; (outer only partial) inner very wide, from 1½ to 4 d., yellow and reddish then a yellowish green band 1 d. wide, then outer, on arc of about 120°, reddish, 1 d. wide.
89	Oct. 21, 10 p. m.	Corona and annulus, M.	10.7	16.9	29.70, rising from 29.65 to 29.74.	9.9	14.8	29.77, steady......	Fine, still, cloudy...	Fine, cloudy, strong wind.	(1) Annulus with undefined edge to 1 d., then, on a background of fine, cirro-cumuli, a faint, rosy corona. (2) Annulus reduced to ¼ d. (3) Thicker cirro-cumuli, annulus gone, reddish corona 3 to 4 d. (4) No cirro-cumuli, corona gone, annulus ¼ d. (5) Annulus 1 d. again.
90	Oct. 22, 10 p. m.	Corona, M.	9.9	14.8	29.77, steady......	8.3	12.1	29.73, falling from 29.78 to 29.70.	Fine, cloudy, light wind.	Overcast, rain.......	Reddish, from 2 to 3 d.
91	Nov. 12, 3 p. m.	Annulus, S.	2.3	9.7	29.65, variable....	5.9	11.1	29.59, variable....	Fine, hazy, cloudy..	Hazy, cloudy, strong wind.	With undefined edge, orange with outer rosy edge, extending to 1 d.
92	Nov. 12, 10 p. m.	Annulus, M.	2.3	9.7	29.63, variable....	5.9	11.1	29.64, variable....	Hazy, cloudy, strong wind.	Fine, sunny, gale...	With undefined edge, extending to 1 d.
93	Nov. 13, 10 p. m.	Annulus, M.	5.9	11.1	29.64, variable....	4.7	12.1	29.91, variable....	Cloudy, strong wind.	Overcast, gloomy, a little rainy.	With red, undefined edge, extending to 1 d.
94	Nov. 16, 3 p. m.	Annulus, S.	1.8	6.7	30.06, steady.....	4.1	11.8	29.99, falling from 30.03 to 29.94.	Fine, cloudy, light wind.	Cloudy, hazy, light wind, overcast, rain.	With undefined edge, orange, extending to 1 d.
95	Nov. 16, 5 p. m.	Annulus, M.	1.8	6.7	30.06, steady......	4.1	11.8	29.98, falling from 30.02 to 29.93.	Fine, cloudy, hazy, still.	Cloudy, hazy, light wind, overcast, rain.	With defined edge, extending to ½ d. from the limb, which it followed closely in outline (gibbous moon), greenish orange; lasted 1 hour.
96	Nov. 18, 10 p. m.	Annulus, corona and halo, M.	*	11.7	30.03, rising from 29.94 to 30.11.	7.3	10.4	30.06, falling from 30.11 to 30.00.	Fine, cloudy, still...	Fine, very hazy, light wind.	(1) Corona, 3 to 4½ d., reddish, with annulus, undefined edge, ¼ d. (2) Annulus alone ½ d. (3) Halo of 22°, milky, and annulus, ½ d. (4) Besides these, a corona 4 to 5 d. (Annulus of two parts, inner with well defined edge, greenish, outer edge (½ d.) pink.)
97	Nov. 19, 6 p. m.	Annulus, M.	7.4	10.4	30.07, variable....	4.1	9.3	30.01, variable....	Fine, very hazy, light wind.	Fine, very hazy, light wind.	With undefined edge, extending to 1 d.
98	Nov. 19, 10 p. m.	Corona, M.	7.3	10.4	30.06, falling from 30.11 to 30.00.	4.1	9.3	30.02, variable....	Fine, very hazy, light wind.	Fine, very hazy, light wind.	Reddish, from 4 to 5 d.
99	Nov. 21, 10 p. m.	Annulus, M.	5.0	7.5	30.09, variable.	0.9	7.1	29.92, falling from 30.10 to 29.72.	Thick fog..........	Overcast, gloomy, little wind.	Very bright, greenish yellow until ½ d. from limb, then a strongly red ring, width 1 d., undefined edge.
100	Dec. 13, 10 p. m.	Corona, M.	2.9	9.7	29.08, variable....	4.1	6.6	28.78, variable...	Gale; just left off raining.	Gale, pouring rain..	Reddish, from 3 to 4 d.
101	Dec. 15, 6 p. m.	Annulus, M.	1.6	4.2	29.43, rising from 28.90 to 29.32.	-0.5	6.9	29.95, rising from 29.82 to 30.03.	Misty, still, frosty..	Thick fog, heavy frost, fine.	With undefined edge, extending to ½ d., following the contour of the gibbous moon.
102	Dec. 16, 6 p. m.	Annulus, M.	-0.5	6.9	29.96, rising from 29.84 to 30.04.	2.9	6.4	30.07, variable....	Cloudy, still........	Overcast, still.......	With undefined edge, extending to ½ d., in middle of large nebulous patch.
103	Dec. 17, 8 p. m.	Annulus, M.	2.9	6.4	30.07, variable....	2.2	†	29.93, falling from 30.04 to 29.83.	Fine, still..........	Overcast, rain.......	With sharp edge, extending to ½ d., then a ring extending to 3 d. from limb, with undefined edge; lasted several hours.
104	Dec. 20, 10 p. m.	Double corona, M.	11.5	12.8	29.69, falling from 29.76 to 29.60.	10.0	11.3	29.60, variable....	Cloudy, strong wind.	Overcast, strong wind, some rain.	Inner very red, 2 d. to 3½ d., outer faint, 5 to 5½ d.

* Gradual increase since November 17. † Gradual increase since December 17.

DEDUCTIONS.

The following deductions are made from the record for the second half of 1907:

Annuli.—Twenty-five observed.

Sun, 11. Five followed by rain, two by wind, one by thunder-storm, three by fine weather.

Moon, 14. Four followed by rain, two by wind, two by wind and rain, one by fog, five by fine weather.

Coronas.—Eighteen observed.

Sun, 7. Four followed by rain, one by wind and rain, two by fine weather.

Moon, 11. Two followed by rain, one by wind, five by wind and rain, three by fine weather.

Halos.—Eleven observed.

Sun, 10. Two followed by rain, four by wind, three by wind and rain, one by fine weather.

Moon, 1. Followed by fine weather.

GENERAL REMARKS.

Altogether, out of fifty-one distinct individual displays, there were—

Followed by rain, 17.
Followed by wind alone, 8.
Followed by wind and rain, 11.
Followed by fog, 1.
Followed by thunder-storm, 1.
Followed by relatively fine weather, 13.

The failures are in greater number than in the previous half year. They are: 3 annuli of the sun, 4 annuli of the moon, 1 combined annulus, corona, and halo of the moon, 2 coronas of the sun, 2 coronas of the moon, 1 halo of the sun.

REMARKS ON THE YEAR.

Observations for the whole of the year 1907 are now available.

TABLE 2.—*Summary of displays and unverified predictions in 1907.*

Quarter.	No. of distinct displays.	No. of failures.	Failures.
			Per cent.
First	19	2	10.5
Second	31	2	6.5
Third	29	7	24.0
Fourth	22	6	27.0
Total	101	17	17.0

If all the phenomena that took place had been observed it would be of some interest to compare the warmer half (2d and 3d quarters) with the colder half (1st and 4th quarters) of the year. However, as it is probable that a large number of displays have escaped attention and such a comparison would be of doubtful utility, we may remark that 60 per cent of the displays occurred in summer (2d and 3d quarters) against 40 per cent in winter (1st and 4th quarters). One fact is evident from the series of observations obtained in the year, and this is that these displays afford a valuable help in the shaping of local short-range forecasts. In Table 3 the observations of the whole year are classified in a more convenient manner in order to ascertain the respective utility of each kind of phenomenon. (The pillar No. 3 is not included.)

TABLE 3.—*Summary of displays and the subsequent weather, Eltham, England, 1907.*

Nature of phenomenon.	Total number of distinct displays.	Number of displays followed in 24 hours by— Rain, hail, or snow.	Wind or storm without rain, hail, or snow.	Wind and rain, hail, or snow.	Fog.	Fine weather.	Failures.
							Per cent.
Annuli, S.	18	7	3	4	......	4	22
Annuli, M.	21	6	4	6	1	4	19
Coronas, S.	9	5	....	2	......	2	22
Coronas, M.	19	3	1	10	1	4	21
Halos, S.	29	7	7	10	3	2	7
Halos, M.	4	2	....	....	1	1	25
Total	100	30	15	32	6	17	17

In the case of a combined display, such as displays Nos. 8[2], 13[2], 37[3], 52[3], 89[4], and 96[4], the most conspicuous phenomenon is chosen as the name of the display, a halo if there is one, or a corona if the halo is absent, the annulus being the least conspicuous of the three.

This Table 3 is exceedingly interesting. It shows first that the failures are equally distributed amongst the various kinds of optical displays, with only one exception, the solar halos, which seem to be an excellent guide for the forecast of approaching meteorological disturbances.

The nature of the disturbance to be expected is next to be considered It is apparent that 68 per cent are of the nature of condensation, or precipitation of water vapor in its various shapes, vesicles, drops, or crystals; 15 per cent are violent movements of the atmosphere, those cases recorded as followed by wind include only the times where the wind attained a velocity greater than those of the first third of Beaufort's scale. The remaining 17 per cent are failures, altho, in several cases, characterized by a very gloomy appearance of the weather, with probable local precipitations elsewhere, or excessive condensation as white mist. This latter phenomenon is a by no means uncommon beginning to a fine, warm, sunny day.

The observations concerning temperature and atmospheric pressure do not show any systematic connection with the observed phenomena.

Minima.—Out of 65 double temperature minima observed, the following minimum is higher in 33 cases (51 per cent).

Maxima.—Out of 58 double temperature maxima observed, the following maximum is higher in 37 cases (54 per cent).

Barometer.—Out of 73 double values of mean atmospheric pressure, the following mean pressure is lower in 40 cases (55 per cent).

At most there is an indication of a rise in the temperature and of a lowering of pressure in a majority of cases. These observations should be discontinued, and, where possible, continuous psychrometric observations made instead, for such observations have a much closer connection with the condensation of the atmospheric vapor, which seems the principal feature of the prevailing meteorological conditions immediately succeeding an optical display of either phenomenon.

REMARKS AS TO THE NATURE AND FORMATION OF THE PHENOMENA.

Some observations made in the second half of the year have led me to modify my opinion as to the annuli being closely allied to halos and due to the same cause. While they sometimes appear simultaneously with halos, when possibly both kind of strata, that producing halos and that producing coronas, are present, they more often occur together with coronas, in a way and under circumstances that could hardly obtain if they were but modified forms of coronas themselves. (See above, observations 71, 89, and 96).

The appearance of coloration in several of the best-marked and more interesting annuli supports this conclusion, as the colors noted (observations 5, 27, 30, 38, 70, 71, 93, 95, 96, and 104) are in agreement to show that the less refrangible end of the spectrum appears on the outside edge, as in the coronas, while this is the reverse for the halos, pointing to diffraction fringes as being the cause of the annuli.

In such diffraction effects, the diameter of the luminous ring produced is inversely proportional to the diameter of the vapor vesicles; it follows that the coarsest globules of vapor must produce the annuli. As the finest displays have,

[2] See Monthly Weather Review, May, 1907, XXXV, table on p. 215.
[3] See Monthly Weather Review, December, 1907, XXXV, table on p. 580.
[4] See Table 1 above.

however, occurred with a sky apparently pure, or with a very light veil, these globules can not be densely packed, as otherwise they would form a visible mist. This thin distribution explains how, in some cases, the light suffers so little absorption that brilliant rings could be seen around the moon *before sunset* (observation 38). On the other hand, the best displays have been observed to be characterized by a fairly sharp edge to the main ring at least (observations 5, 30, 38, 70, 95), with the exception of the annulus of 99, and diffraction patterns are known to be sharpest when the screening particles are of very uniform size. This condition seems to be difficult of realization in agglomerations of large vesicles of water vapor, while quite possible with very small vesicles. Such homogeneity of size would, moreover, produce several colored rings, while only one could be seen generally. In some cases, two or three rings were observed, but they usually did not extend farther than $1\frac{1}{3}$ to $1\frac{3}{4}$ diameters from the limb of the moon (observations 5, 31, 38, 70, 99, 103). The majority of the annuli observed extended only to about $\frac{1}{2}°$ from the limb, while the coronas are situated at a minimum distance from the limb of $1\frac{1}{2}°$ to $2°$. A very few intermediate sizes were observed (observations 71, 103).

THE DUTY OF THE GOVERNMENT TO PROTECT THE PEOPLE FROM SWINDLERS.

Under existing laws of the United States it is not allowable to use the United States mails to promote lotteries or any form of swindling. The public authorities do not wait for the victim to bring suit but do so themselves promptly in the name of the people.

It is the duty of the Editor to call attention to the fact that the folly of any human attempt to make rain or to alter the weather in any way, has been so abundantly demonstrated in this country, in Europe, in Australia, in New Zealand, and elsewhere, that it is high time our law givers made it a penal offense to promise to do this or to secure money under such false pretenses as these promises are.

It is not enough to say that the "operator" makes no promise, that he only experiments and performs and leaves it to the public to draw its own conclusion. The good natured public is willing to give the fakir a dollar and stand by looking on with idle curiosity. The local authorities want a crowd at the county fair and the rain-maker draws, just as did Barnum's wooly horse seventy years ago. Well, put him in a cage and let him draw, but stop this praying and sacrificing, dynamiting, and steaming. Let the deluded ones go elsewhere to spend their money.—*C. A.*

THE OBSERVATORY ON MOUNT ETNA.

Under the above title in the MONTHLY WEATHER REVIEW for April, 1908, p. 102, we erroneously referred to Prof. G. B. Rizzo, as director of the observatory near the summit of Mount Etna, whereas it is really Prof. Annible Riccò who is director of the summit observatory and is also director of the astronomical observatory at Catania, the official name of which is Regio observatorio astronomico ed Etneo.

On the other hand Professor Rizzo, who is director of the observatory of Messina and of the Institute for Terrestrial Physics and Meteorology of the Royal University, at Messina, writes that in studying solar radiation he includes observations with the Ångström electric compensating pyrheliometer both at the Rocciamellone and at the summit also, by the kind cooperation of the director Professor Riccò.—*C. A.*

THE HEAVIEST RAINFALL IN ONE HOUR.

By Prof. A. G. MCADIE. Dated San Francisco, Cal., July 8, 1908.

In connection with the note on a cloudburst near Shasta, Cal., in the MONTHLY WEATHER REVIEW for April, 1908, p. 97, and the article on cloudbursts, by Mr. Edward L. Wells, Section Director, Boise, Idaho, in the Year Book for 1906, p. 325, it seems proper to call attention to a well authenticated case of a cloudburst which appears to have been overlookt. At Campo, Cal., August 12, 1891, a rainfall of 292 millimeters in one hour occurred, or at the rate of 4.87 millimeters per minute. This is probably the heaviest rainfall [in one hour] on record. At least it heads the column of heaviest rainfall given by Hann in his Lehrbuch der Meteorologie, 2d edition, p. 272.

The details of this cloudburst, and the rainfall measurements, by Mr. Archibald Campbell, of Campo, were sent to the Central Office in a communication previous to the 18th of April, 1906. Unfortunately all of our records have been destroyed. The rate of precipitation is more than twice that given by Mr. Wells, in the Year Book for 1906, in the article on cloudbursts, as occurring at St. Louis, on August 15, 1848. At Campo 11.50 inches (292.1 millimeters) fell in twenty-four hours. This is both the greatest rainfall in twenty-four hours and in one hour.

From the MONTHLY WEATHER REVIEW for August, 1891, we find that this was the heaviest monthly, daily, and hourly rainfall reported during the month of August up to 1891.

Original notes made by S. E. Gaskill, cooperative observer at Campo, Cal., regarding the cloudburst of August 12, 1891.

> On the 12th of August had a cloudburst. One heavy thunder-cloud came up and it rained about thirty minutes very hard, raising the water in the streams flood high by the gage. I could not tell [how much water had fallen because] it was running over, emptied it and then another cloud came up and the one that had past over drew back and the two came together and it poured down whole water nearly. I went to the gage again in thirty minutes and it was running over and the reservoir was nearly half full, I emptied it out of the gage and did not stop to measure the reservoir; after the shower was over I went out to measure the water and the gage was gone, carried off by the flood. It was exciting times with us about that time.

The Weather Bureau is not aware of any rainfall in the United States, which has exceeded the above record for one hour at Campo, Cal.—*C. A., jr.*

STUDIES IN THE FORMATION OF FROST.

By DEWEY A. SEELEY, Observer. Dated Peoria, Ill., May 8, 1908.

For some years past the writer has taken an active interest in temperature variations near the surface of the soil, and in the moisture and temperature conditions which accompany the formation of frost. Over two years ago, January 22, 1906, I enumerated a number of problems which I intended to work upon. They were as follows:

(1) What becomes of the heat of condensation during the formation of dew and frost?

(2) Are fluctuations in temperature at night due to ascending and descending currents of air?

(3) How does the color of the soil affect the amount of frost formed?

(4) What effect does a covering of vegetation over the ground have upon its temperature and the amount of frost deposited?

(5) What are the sources of that moisture which forms as dew and frost, and how much does each contribute?

(6) What is the effect of smudging, flooding, cultivating, etc., upon the formation of frost?

(7) How far does the temperature fall on clear, still nights below the dew-point as determined in the late afternoon or early evening?

I have been at work upon suitable experiments and observations during the past two years, but failed to secure many definite results on account of the complexity of the problems and the impossibility of eliminating nonrelated causes and effects. However, I desire to report what little I have accomplished.

In regard to (1) *What becomes of the heat of condensation during the formation of dew and frost?* I have tried to determine whether there was any material warming of the air near the ground while such condensation was going on. The only instruments available for this work were cylindrical-bulbed, minimum thermometers and registering thermographs, so that the results obtained were rather crude and only approximately accurate. But I think they point to definite results.

A soil thermograph was sent to this station in September, 1906. This instrument was placed beside the regular station thermograph in the shelter and there compared with the latter for several days, with the result that the traces made by the two instruments were found to be nearly identical. Accordingly an attempt was made to secure a record of the temperature variation of the air at the surface of the ground during the formation of dew and frost. The bulb of the soil thermograph was placed about one inch above the sod of a grass-covered plot and traces secured of the temperature variations in this location, the object being to determine whether there was any appreciable increase in the temperature of the air as the dew and frost formed on the grass beneath. Of course there were irrelative factors entering into the experiment at each stage, including the radiation and absorption of heat by the bulb itself, the deposition of moisture on the bulb, etc., and yet, notwithstanding these, the temperature of the thermograph bulb probably followed more or less closely the temperature changes taking place in the air which surrounded it. On numerous occasions, when thus exposed, the soil thermograph registered a marked rise in temperature at the time of the heaviest deposit of dew and frost. This instrument recorded much more marked changes than those registered by the station thermograph located about 10 feet above it, in the instrument shelter. The station thermograph, however, usually exhibited evidence of this warming influence either by an actual rise or a retardation in the rate of the fall which had been taking place.

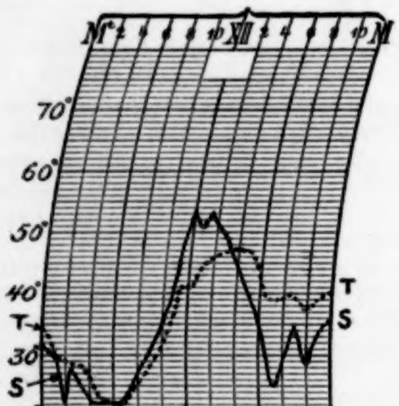


Figure 1. S—Record by the soil thermograph on the sod. T—Record by the station thermograph, 10 feet above, in the shelter.

The special minimum thermometers, exposed with their bulbs in similar positions to that of the soil thermograph, registered very closely with the latter, which would indicate that the true air temperature was at least approached by both sorts of instruments. The results were practically the same even when the thermometer bulb was wrapped in a growing leaf, and exposed with this covering. On one occasion the bulb of the thermograph was so covered, when exposed near the ground, without apparently affecting the result.

Figure 1 presents a copy of the traces made by the soil and ordinary thermographs. It is similar to several others obtained under the same conditions, i. e., on clear, still nights when heavy deposits of dew or frost were formed. From this evidence I am of the opinion that a considerable amount of the heat given off during the condensation of vapor as frost and dew, is retained in the saturated air near the ground level and also by the foliage of the plants themselves.

In regard to the second problem, *Are fluctuations in temperature at night due to ascending and descending currents of air?* I had no means of determining whether such currents were taking place except by noticing the direction of smoke as it left nearby chimneys and smoke-stacks. On several nights I carefully watched the motions of smoke during the periods that these marked temperature fluctuations were taking place, but could not find any indications of marked ascending and descending currents. I am inclined to think that if any such currents occur they result from, rather than cause the nocturnal increase or decrease in temperature near the surface of the ground.

In order to investigate *the influence of the color of the soil* on its temperature and the amount of frost deposited upon it, five glass plates of the same size were colored, respectively, red, green, gray, brown, and black. These plates were weighed and then exposed under exactly the same conditions, for frost to form upon them. The weight of the frost deposit did not differ materially on the several occasions that the experiment was tried. The amount of frost which forms on different soils depends more upon the texture of the soil and its water content than upon its color.

The influence of a surface covering of vegetation on the temperature of the soil is very marked, however. In order to determine this point four minimum thermometers were exposed as follows: No. 1, about a half inch below the surface of bare ground; No. 2, the same distance below the surface of a grass covered soil; No. 3, laid on the surface of the bare ground; and No. 4 placed in the grass, care being taken to prevent any blades from covering the bulb. These four thermometers were read on eighteen mornings when the air was clear, and still, and also read in the middle of the afternoon on thirteen days when the weather was clear, with light wind, with the results presented in Table 1, below.

Table 1.—*Soil temperatures observed at Peoria, Ill.*

No.	Exposure of thermometer bulb.	Mean minimum temperature.	Mean of 13 afternoon readings.
		°	°
1	Bulb one-half inch below the surface of bare ground	30.1	46.2
2	Bulb one-half inch below the surface of sod	36.2	47.9
3	Bulb on the surface of bare ground	27.3	45.0
4	Bulb on surface of sod, but not in contact with grass	23.9	43.0

The variations in the minimum readings obtained were surprisingly uniform. Thermometer No. 2, whose bulb was embedded in the sod, registered highest, averaging about 6° higher than No. 1, similarly exposed in naked soil. Thermometer No. 4, lying in the grass, recorded 3.4° lower than thermometer No. 3, which lay on the bare ground.

It will be noticed that the soil beneath the grass was warmer both at night and during the day than the naked soil, but the temperature of the air above the grass was lower in both cases than over the bare ground.

No means could be devised for investigating *the sources of that moisture which forms as dew and the amount which each source contributes.* It was noticed, however, that dew began to

form first near the roots of the grass, while the tops of the blades were still dry, indicating that part of the moisture, at least, came from the ground. Water in the soil, warmed by the sun's rays, continued to evaporate during the evening, but was condensed again upon coming in contact with the cooler grass blades. The next portion of the grass blade to bear dew was the tip end. Here the dewdrop forms before the middle of the blade becomes moistened. Probably this moisture comes almost entirely from the air. Undoubtedly one source of dew-forming moisture is the water exuded from the stomita of the plant. But perspiration by the plant ceases about as soon as the air becomes saturated, therefore the amount from this source can not be great. Just how much each source contributes is impossible to estimate.

Little work was done to determine *the effects of smudging, flooding, and cultivating the ground upon frost formation.* A small area of ground was dug up and raked over, and a thermometer, with bulb encased in a growing onion leaf was exposed over it. Another instrument, similarly mounted, was exposed over soil which had not been cultivated for some time. On several mornings both thermometers were read, and in every case the former instrument registered about 2° higher than the latter. These observations suggest the advisability of thoroly cultivating the soil as a measure tending to protect against the destructive effects of frost. A thoro wetting of the soil seemed to have but little influence on the temperature of the vegetation growing upon it.

In order to determine how far the temperature falls on clear, still nights, below the dew-point recorded late in the afternoon before, the records of the Peoria station were gone over for one year, and the data selected which could be used to investigate this point. The dew-point, as recorded at 7 p. m.,[1] and the minimum temperature registered the following morning on 60 nights, were tabulated and the differences computed. From these it was found that on the average the minimum temperature went 2.9° below the 7 p. m. dew-point. In but three cases did the temperature fall more than 10° below the dew-point recorded at 7 p. m.

By examining thermograph traces made during clear weather with light winds, it will be observed that the temperature decline goes on much more rapidly during the first part of the night before the dew-point is reached. After it has fallen to that point the decline is much less rapid, and in some cases the fall is entirely checked, or changed to a rise. These all point to the same conclusion, that a portion of the heat of condensation in the formation of dew and frost is retained by the lower air.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Librarian.

The following have been selected from among the titles of books recently received, as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies. Most of them can be lent for a limited time to officials and employees who make application for them. Anonymous publications are indicated by a ——.

Aachen. Meteorologisches Observatorium.
Deutsches meteorologisches Jahrbuch ... 1906. Aachen. Jahrgang 12. Karlsruhe. 1908. 56 p. f°.

Agra and Oudh. Meteorologist.
Administration report 1907–8. Allahabad. 1908. 4 p. f°.
Brief sketch of meteorology ... 1907. Allahabad. 1908. 7 p. f°.

Australia. Commonwealth meteorologist.
A new form of pressure anemometer. By H. A. Hunt. Melbourne. [1908.] 10 p. 8°.
Rainfall map of the commonwealth of Australia. Bull. no. 2 ... by H. A. Hunt. Melbourne. 1908. 11 p. 8°. 1 map. 56 x 61 cm.

Bargmann, A.
Himmelskunde und Klimakunde. Lehrplan, Beobachtungen und Lektionen. Leipzig. 1908, viii, 215 p. 8°.

[1] This is 7 p. m. local standard time, or ninetieth meridian standard.

Behre, Otto.
Das Klima von Berlin. Berlin. 1908. 158 p. 8°.

Bendel, Johann.
Wetterpropheten ... Regensburg. 1904. 166 p. 8°.

Carnegie institution.
Handbook of learned societies and institutions. America. Washington. 1908. 592 p. 8°.

Crelle, A. L.
Rechentafeln ... Neue Ausgabe. Berlin. 1907. n. p. f°.

Dewar, Daniel.
Atmospheric movements 1908–9. Glasgow. 1908. 3 p. 16°.

Drygalski, Erich von.
Allgemeiner Bericht über den Verlauf der Deutschen Südpolar-Expedition. Mit Vorbemerkungen von Ferdinand Freiherr v. Richthofen und einem Anhang, Bericht über die Arbeiten der Kerguelen-Station, von Karl Luyken. Berlin. 1903. viii, 73 p. 4°.

Erman, Adolph.
Reise um die Erde durch Nord-Asien und beiden Oceane in den Jahren 1828, 1829 und 1830. Berlin. 1833–1848. 3 v. 8°.
11 Tafeln des Atlas zu Erman's Reise um die Erde. Ausgegeben mit den dritten Bande der ersten Abtheilung. Berlin. 1848. 11 sheets. 45 x 31 cm.
Verzeichniss von Thieren und Pflanzen, welche auf einer Reise um die Erde gesammelt wurden. Berlin. 1835. 64 p. 17 pl. f°.

Ficker, Heinz von.
Zur Meteorologie von West-Turkestan. Wien. 1908. 35 p. f°.

Findeisen, F.
Praktische Anleitung zur Herstellung einfacher Gebäude-Blitzableiter. Zweite Auflage. Berlin. 1907. vi, 126 p. 8°.

France. Service hydrométrique du bassin de la Seine.
Observations sur les cours d'eau et la pluie centralisées ... 1906. n. p. n. d. 7 sheets. 60 x 46 cm.
Résumé des observations centralisées ... 1906. n. p. n. d. 25 p. f°.

Freybe, Otto.
Klima- und Witterungskunde. Hannover. 1908. iv, 71 p. 12°.

Froc, Louis.
Les tempêtes dans la province maritime du Fou-Kien (Chine). Extrait de la Revue des questions scientifiques, octobre, 1907. 8p. 8°.

Frost, J.
Agrarverfassung und Landwirtschaft in den Niederlanden. Berlin. 1906. vii, 495 p. 4°. (Berichte über Land- und Forstwirtschaft im Auslande. Mitgeteilt vom Auswärtigen Amt. Buchausgabe Stück 12.)

Gerdien, H.
... Untersuchungen über die atmosphärischen radioaktiven Induktionen. Berlin. 1907. 75 p. 4°. (Abhandlungen der Königlichen Gesellschaft der Wissenschaften zu Göttingen, mathematisch-physikalische Klasse. Neue Folge. Band 5. Nro. 5.)

Hale, George Ellery.
The study of stellar evolution. Chicago. 1908. xi, 252 p. civ pl. 8°.

Hamburg. Deutsche Seewarte.
Deutsche überseeische meteorologische Beobachtungen. Hamburg. 1908. 129 p. f°.

Hellmann, G[ustav].
Meteorologische Volksbücher. Berlin. 1895. 68 p. 4°.

Hungary. M. kir. orsz. meteorologiai és földmegnességi intézet.
Nagtagyos 1901–7. évi meteorologiai megfigyeléseinek eredeményei. Budapest. 1908. 16 p. 8°.

India. Meteorological department.
Memorandum on the meteorological conditions prevailing in the Indian monsoon region before the advance of the southwest monsoon of 1908, with an estimate of the probable distribution of the monsoon rainfall in 1908. Simla. 1908. 3 p. f°.

Kienast, Hermann.
Das Klima von Königsberg i. Pr. Teil 3. Der jährliche Gang der Lufttemperatur, dargestellt auf Grund der Beobachtungen aus den Jahren 1848–1906. Königsberg. 1907. 45 p. f°.

Marangoni, Carlo.
Fantasie sulla grandine. Firenze. 1899. 7 p. 8°. (Estratto dagli Atti della R. accademia dei Georgofili. Anno 1899. v. 22. Dispensa 2.)

Merzifun (Asia Minor). Anatolia college.
Meteorological records. 1907. 1 sheet. 24 x 36 cm. n. p. n. d.

Moncalieri. R. collegio Carlo Alberto. Osservatorio meteorologico.
Riassunto delle osservazioni meteorologiche fatte al Grand Hôtel du Mont Cervin (Giomein-Valtournanche) in Valle d'Aosta durante la stagione estiva (luglio, agosto, settembre 1906). Perugia. 1907. 15 p. 8°.

Naturforschender Verein in Brünn.
25. Bericht der meteorologischen Commission.
Ergebnisse der meteorologischen Beobachtungen ... 1905. 158 p. 8°. Brünn. 1908.
Verhandlungen ... 1906. Brünn. 1907. 246 p. 8°.

Oppokov, E.
... Sur l'accumulation et la consommation de l'humidité dans le sol des bassins des fleuves de plaines. St. Pétersbourg. 24 p. 8°. (11me Congrès-Saint-Pétersbourg, 1908.)
... Variations périodiques de longue durée du débit et des depôts atmosphériques dans les bassins fluviaux. St. Pétersbourg. 39 p. 12°. (11me Congrès-Saint-Pétersbourg, 1908.)

Philippine islands. Weather bureau.
Annual report... Part 2, 1905. Manila. 1908. 386 p. 4°.

Queensland. Water supply department.
Annual rainfall, 1906. Brisbane. [1908.] 1 sheet. 69 x 102 cm.

Réthly, Anton von.
Die meteorologischen Beobachtungen auf der Babiagóra und in Arvapolhora... 1906. Bielitz. n. d. 12 p. 8°.

San Fernando. Instituto y observatorio de marina.
Anales. Seccion 2. Observaciones meteorológicas, magnéticas y séismicas. 1907. San Fernando. 1908. viii, 157 p. f°.

Scheiner, J[ulius].
Populäre Astrophysik. Leipzig. 1908. vi, 718 p. 8°.

Supan, Alexander.
Grundzüge der physischen Erdkunde. Vierte, umgearbeitete und verbesserte Auflage. Leipzig. 1908. ix, 934 p. 8°.

Taylor instrument company.
Weather and weather instruments. Rochester. 1908. 175 p. 12°.

Trieste. I. r. osservatorio marittimo.
Rapport annuale... 1904. 21 v. Trieste. 1908. 115 p. f°.

Uruguay. Instituto nacional para la prediccion del tiempo.
Promedios mensuales. Año 1907. Montevideo. 1907. 1 sheet. 43 x 81 cm.

Zöppritz, August.
Prognosen aus den Gestirnstellungen für das Jahr 1908. Stuttgart. [1907. 31 p.] 8°.

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Librarian.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers or other communications bearing on meteorology or cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled; it shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau. Unsigned articles are indicated by a ——

Aeronautics. New York. v. 3. August, 1908.
Blair, W. R. Kite manipulation and the record flight. p. 26-28.

Geographical journal. London. v. 32. August, 1908.
Rawson, H. E. The southern cyclonic belt. p. 178-179.

Meteorological society of Japan. Journal. Tokio. v. 27. July, 1908.
Ishida, M. On the characteristic conditions of rainfall over the back Japan in winter. p. 17-19.
Ogawa, T. Climate of Fusan. p. 19-20.

Nature. London. v. 78. 1908.
Backhouse, T. W. The "sky-coloured clouds" or twilight glows. (August 20.) p. 367.
Shaw, William N[apier]. [Presidential address, Section A, British Association, Dublin, 1908.] (September 3.) p. 425-431.
—— The late M. Mascart. (September 10.) p. 446-448.

Popular astronomy. Northfield, Minn. v. 16. August-September, 1908.
Roe, E. D., jr. Wind pressure on an observatory dome. p. 424-426.

Royal society. Proceedings. London. ser. A. v. 81. A. 546.
Watson, Herbert Edmeston. The spectrum of the lighter constituents of the air. p. 181-194.
Moore, Richard B. An investigation of the heavy constituents of the atmosphere. p. 195-209.

Science. New York. New series. v. 28. 1908.
Livingston, Burton Edward. A simple atmometer. (September 4.) p. 319-320.
Barrell, Joseph. Schaeberle and geological climates. (September 18.) p. 371-373.
Schaeberle, J. M. An explanation of the cause of the eastward circulation of our atmosphere. (September 25.) p. 415-416.

Scientific American supplement. New York. v. 66. 1908.
Berg, H. A short account of "lightning tubes." (August 15.) p. 109.
—— Strange forms of the setting sun. (September 12.) p. 175.

Symons's meteorological magazine. London. vol. 43. August, 1908.
Bates, D. C. Report upon dry period and rain-making experiments at Oamaru, New Zealand. p. 137-138.

Annales de géographie. Paris. 17 année. 15 juillet 1908.
Denis, Pierre. L'état de Saint Paul, d'après les travaux de la commission géographique. p. 328-343. [Le climat et la végétation, p. 335-339.]

Ciel et terre. Bruxelles. 29me année. 1908.
P[hilippot], H. Lueur crépusculaire. [June 30.] (16 juillet.) p. 252-254.
V., J. La mesure de la neige. [Abstract of paper by Angot describing a new snow gage.] (1 septembre.) p. 325-327.

France. Académie des sciences. Comptes rendus. Paris. Tome 147. 1908.
Durande-Gréville, E. Le premier crépuscule du matin et le second crépuscule du soir. (3 août.) p. 318-320.
Deslandres, H. Sur la recherche d'une classe particulière de rayons qui peuvent etre émis par le soliel. (17 août.) p. 373-375.
Violle, J. Sur un orage à grêle ayant suivi le parcours d'une ligne d'énergie électrique. (17 août). p. 375-377.
Esclangon, Ernest. Sur les illuminations crépusculaires. (24 août.) p. 408-411.

Revue néphologique. Mons. Juillet 1908.
—— Lueurs crépusculaires du 30 juin et du 1 juillet. p. 244-245.

Société belge d'astronomie. Bulletin. Bruxelles. 13 année. Juillet-août. 1908.
Gheury, M. E. J. La variation diurne de la pression atmosphérique. p. 254-258.

Société météorologique de France. Annuaire. Paris. 56 année. Mai 1908.
Angot, Alfred. Sur le calcul des observations pluviométriques. p. 125-128.
Brunhes, B. Sur la mesure directe de la composante verticale du magnétisme terrestre. Application à la chaine des Puys. p. 129-131.
Garrigou-Lagrange, M. P. La pluie et le régime des cours d'eau. p. 132-134.
Mèmery, H. Le refroidissement de la deuxième quinzaine du mois d'avril. (Relation probable avec les phénomènes solaires.) p. 140-142.

Annalen der Hydrographie und maritimen Meteorologie. Berlin. 36. Jahrgang. Juli 1908.
Grossman. Die Beziehung zwischen den Temperaturen des nordatlantischen Ozeans und von Nordwest- und Mitteleuropa. p. 333-348.

Annalen der Physik. Leipzig. Band 26. 1908.
Holborn, L. & Henning, F. Ueber das Platinthermometer und den Sättigungsdruck des Wasserdampfes zwischen 50° und 200°. p. 833-883.

Gaea. Leipzig. 44. Jahrgang. Oktober, 1908.
—— Die Beziehung zwischen den Eisverhältnissen bei Island und der nordatlantischen Zirkulation. p. 578-582.
Meyer, G. Ueber die periodischen Klimasschwankungen. p. 588-591.
—— Zur Meteorologie der Adria. p. 591-592. [Abstract of article by Hann.]
—— Der am 6. und 7. Januar 1908 in Norddeutschland beobachtete Staubfall. p. 593-594.
—— Der Einfluss der Grossstädte auf die Luftfeuchtigkeit. p. 607-610.

Meteorologische Zeitschrift. Braunschweig. 25. Band. Juli, 1908.
Kähler, Karl. Registrierungen des luftelektrischen Potentialgefälles an nahe benachbarten Stationen. p. 289-299.
Smirnow, D. Ueber das Aktinometer Violle-Savélief. p. 299-312.
Rudzki, M. P. Nordschein am 30. Juni in Krakau. p. 313.
Kramer, Jan. Zum Klima von Sitka. p. 315-320.
Woeikow, A. Regenfall und Abfluss in den Tropen nach: Dr. A. Merz: Beiträge zur Klimatologie und Hydrographie Mittelamerikas. H. L. Abbot, Rainfall and outflow in the valley of the Chagres. p. 326-330.
McAdie, Alexander G. Die wahre Mitteltemperatur von San Francisco, Kalifornien. p. 330-331.

Prometheus. Berlin. 19. Jahrgang. 13 Mai 1908.
Kleinschmidt, Ernst. Die Drachenstation am Bodensee. [Illustrated.] p. 516-522.

Wiener Luftschiffer-Zeitung. Wien. 7. Jahrgang. August, 1908.
—— Die Drachenstation am Bodensee. p. 181-183.

Hemel en Dampkring. Den Haag. 6. Jaargang. Augustus 1908.
Hartman, Ch. M. A. De talrikheid von stortbuien. p. 52-54.
Monné, A. J. Meteorologishe waarnemingen in West-Indie. p. 54-56.
De Veer, C. L. Een eenvoudig middel, om barometers te controleeren met behulp van de dagelijks in de dagbladen gepubliceerde luchtdruk-waarnemingen van de Nederlandsche stations. p. 56-60.

Reale accademia dei Lincei. Atti. Roma. v. 17. 2. sem. Fasc. 3. 1908.
Allesandri, G. La radiazione attinica del sole al Monte Rosa. Osservazione eseguite alla Capanna Regina Margherita coll'attinometro fotoelettrico di Elster e Geitel. p. 113-118.

Società aeronautica Italiana. Bollettino. Roma. Anno 5. Giugno 1908.
Gamba. La deviazione del vento coll'altezza. p. 150-151.

NOTES FROM THE WEATHER BUREAU LIBRARY.

By C. Fitzhugh Talman, Librarian.

THE DEATH OF PROFESSOR MASCART.

These notes (March, 1908, p. 71) recently contained a brief notice of the affecting scene at Poissy, on September 12, 1907, when Professor Mascart took leave of his colleagues of the International Meteorological Committee, over which he had presided for fourteen years. His health had been declining for some time, and he was not strong enough to make the short journey to Paris, where the regular sessions of the committee were held. Now comes the sad news of the death of this distinguished meteorologist and physicist on August 26, 1908, at the age of 71.

Nature (London) of September 10 contains a comprehensive account of Professor Mascart's scientific career, while a somewhat more intimate sketch of his life and character appears in La Nature (Paris) of September 12.

Éleuthère Élie Nicolas Mascart was born at Quarouble, near Valenciennes, February 20, 1837. He was graduated from the École Normale Supérieure, taught physics for several years, and in 1878, when the meteorological service of France was separated from the astronomical observatory, he became the first director of the independent service—the Bureau Central Météorologique. He retired from the directorship January 1, 1907, and was succeeded by Professor Angot.

The branches of physics, besides meteorology, in which Professor Mascart was especially interested were electricity and optics, and his most notable contributions to meteorology related to atmospheric electricity and atmospheric optics. His "Traité d'optique" has, in fact, been the principal reference book on meteorological optics down to the very recent appearance of the (still incomplete) "Meteorologische Optik" of Pernter.

TRAVELS OF AN AUSTRALIAN METEOROLOGIST.

Mr. H. A. Hunt, Commonwealth Meteorologist of Australia, who has been despatched by his government upon a tour of investigation of the principal meteorological services of the world, recently arrived in America by way of the Pacific, visited some of the western coast stations of the U. S. Weather Bureau and of the Meteorological Service of Canada, the headquarters of the latter service at Toronto, and the Central Office of the Weather Bureau at Washington, where he spent ten days early in September. He also visited the Research Observatory of the Weather Bureau at Mount Weather, Va. Mr. Hunt sailed from New York September 17 for Hamburg, to visit the Deutsche Seewarte and take part in the celebration of the twenty-fifth anniversary of the German Meteorological Society.

The Commonwealth Meteorological Bureau of Australia has but recently been formed, thru the amalgamation of the several state services of that country (see Monthly Weather Review, May, 1907, p. 2 8). The founding of this national service was somewhat analogous to, and nearly contemporary with, the organization of the new Public Weather Service of Germany. It is interesting to note that in both cases the governments concerned sent representatives abroad to glean ideas and suggestions from the experiences of the meteorological bureaux of foreign countries. Germany sent Doctor Polis, of Aachen, to America for this purpose in the autumn of 1907.

BULLETINS OF THE AUSTRALIAN METEOROLOGICAL SERVICE.

Almost coincidently with Mr. Hunt's arrival in America the post brought us his "Climate and meteorology of Australia," which was issued in March, 1908, as Bulletin No. 1 of the new Commonwealth Bureau. It is reprinted from the 1901-1907 "Yearbook of the Commonwealth of Australia," with the correction, however, of the numerous typographical errors that slipped thru the press in the earlier publication. This is a compact little account of Australian climate and weather, based on observations down to and including 1906, special attention being given to the meteorology of the state capitals.

Bulletin No. 2 of the same bureau, issued July, 1908, is entitled "Rainfall map of the Commonwealth of Australia," and is also by Mr. Hunt. Besides eleven pages of text it comprises a large chart of the mean annual rainfall of Australia and Tasmania, based on the records of nearly 700 stations for the decade 1897-1906. One object of this publication is stated to be "to dispel many of the erroneous impressions that are current respecting the rainfall of Australia and Tasmania." The author says:

> When compared with other continents the quantities and distribution of rainfalls over Australia are not so unfavorable as is generally supposed. * * * Comparing the rainfalls of the chief cities of the rest of the world with those of Australia, we find that Bombay, Calcutta, Colombo, Singapore, and Hongkong are the only places out of a list of 42 that exceed the totals of Sydney and Brisbane. Perth has a greater annual rainfall than New York, and more than that of 28 other cities of the 42. Hobart nearly equals London, which Melbourne exceeds by an inch. Eleven of the 42 cities mentioned have less rain than Hobart.

METEOROLOGY AT THE BRITISH ASSOCIATION.

At the Dublin meeting of the British Association, which opened September 2, 1908, the Mathematical and Physical Section was presided over by Dr. W. N. Shaw, Director of the British Meteorological Office. Doctor Shaw's presidential address, which is published in Nature of September 3, 1908, is of interest to all meteorologists. In reviewing the work of the Meteorological Office the director calls attention to the fact that arrears in the publication of data are being rapidly made up, so that by the end of this year "six weeks will be the full measure of the interval between observation and publication in all departments." He also makes the interesting announcement that on July 1, 1908, the morning hour of observation at 27 out of the 29 telegraphic stations in the British Isles was changed from 8 a. m. to 7 a. m., so that there is now a strictly synchronous system of observations for western and central Europe. Dealing with the question of the economical administration of his office, and the perennial demand for tangible "results," Doctor Shaw borrows his metaphors from "The Merchant of Venice" and shows how the demands of the scientific Shylocks are frequently met with the news that some unpromising argosy of investigation that started on its voyage long ago "hath richly come to harbor suddenly." Several recent discoveries of British meteorologists are cited in illustration, one of the most interesting being that of the semidiurnal variation in the velocity of the southeast trade wind, corresponding to the semidiurnal variation of barometric pressure. This discovery is the result of a recent elaboration of anemometric observations at St. Helena dating from 1891.

At the same meeting was held an important discussion on the isothermal layer of the atmosphere, an abstract of which will be published in a later number of the Review.

THE WEATHER OF THE MONTH.

By Mr. P. C. Day, Acting Chief, Climatological Division.

PRESSURE AND WINDS.

The distribution of mean atmospheric pressure for August, 1908, over the United States and Canada, is graphically shown on Chart VI, and the average values and departures from the normal are shown for each station in Tables I and III.

Nearly normal pressure prevailed during the month over the entire area of the United States and Canada. Over the districts from the Mississippi Valley eastward to the Atlantic the average pressure was slightly above 30.00 inches, while on the Pacific slope it ranged from about 29.90 over the southern

coast of California to slightly more than 30.05 on the coasts of Oregon and Washington.

The average pressure was generally less than that of the preceding month over nearly all districts in the United States and Canada, the exceptions were the Great Valley of California, portions of the Canadian Northwest Territories, and the extreme eastern portion of the Maritime Provinces, where the pressure was slightly greater than that for July.

Pressure was above the normal by small amounts over practically all portions of the United States and also over Canada as far as observations extend.

The greatest positive departures from the normal pressures, + .04 to + .06 inch, occurred over the Central Rocky Mountain and Plateau districts, over extreme eastern Canada, and over western Oregon, Washington, and British Columbia. There was a small area including eastern Georgia and western South Carolina where the pressure was about normal or slightly below.

Southerly winds prevailed over the lower Mississippi Valley, most of the Plains region, and along the Atlantic coast, and northerly or northwesterly winds prevailed over the Pacific slope and generally along the northern border.

There was a general excess of wind movement along the Atlantic coast, over the Lake region, upper Mississippi Valley, and on the Pacific slope, while in the Ohio Valley, west Gulf States, and generally over the Rocky Mountain districts storm activity was somewhat less than the average.

TEMPERATURE.

The mean temperature of the month as a whole was below the normal from the Mississippi Valley westward to the Pacific, except over Oregon, portions of southern and eastern Washington, and northern California. It was also below normal over the lower Lake region, upper Ohio Valley, and from the southern Appalachian Mountains northeastward to New England.

Over the Gulf States and a narrow strip from the lower Ohio Valley northward to the upper Lakes, the average temperature was above the normal. The departures from normal temperatures were within moderate limits.

High maximum temperatures prevailed over the interior valleys of California and Oregon at intervals during the month, and they were unusually high over portions of the more northern districts between the Lake region and the Rocky Mountains during the first week of the month.

Minimum temperatures were near the freezing point over the Interior of New England, the northern part of North Dakota, and at points in the northern Rocky Mountain districts, but elsewhere they were moderate, remaining generally above 50° in all the great agricultural districts.

PRECIPITATION.

The distribution of precipitation during August, 1908, is graphically shown on Chart IV by appropriate shading or by figures representing the actual amount of fall over districts, the topography of which is too varied to admit of approximately correct shading.

Heavy rains occurred over the Atlantic coast districts from Chesapeake Bay southward, where, except in portions of southern Georgia, amounts from 8 to 15 inches were generally recorded. Some heavy falls, ranging from 6 to 8 inches, also occurred over portions of southern New England, southeastern New York, northern New Jersey, and over a narrow region from central Iowa southward to eastern Texas and southern Louisiana.

The usual summer rains occurred over the greater part of Arizona and New Mexico, and they extended northward into Colorado and Utah. Some unusually heavy rains occurred in the mountain regions of southern California, and there was a small area in extreme northwestern Minnesota with precipitation from 3 to 7 inches.

Over portions of the Ohio Valley and lower Lake region the monthly amounts were less than 2 inches, and in the southern portions of Indiana and Illinois less than 1 inch fell. No rain occurred over the greater part of central and northern California, and the amounts over the remaining States of the Pacific coast and over most of the Plateau districts were less than 1 inch, except in extreme western Washington.

Precipitation was above the normal along the entire Atlantic coast from the central portions of South Carolina and Georgia to the Maritime Provinces of Canada, and also over southern Florida. Over portions of northern and eastern Georgia, northern South Carolina, and eastern and central North Carolina the amounts were from 6 to more than 10 inches above the normal fall. Amounts 2 to 4 inches above the normal occurred over portions of lower Michigan and the adjacent parts of Ohio, Indiana, and Illinois, and there were small excesses locally in northwestern Minnesota, in portions of the lower Missouri Valley, Kansas, and Texas, generally over the Rocky Mountain region, and in portions of southern California.

Over northern Arizona and the southern portions of Utah and Colorado the month was unusually rainy, with frequent thunderstorms. The rivers and small streams carried large volumes of water, and the supply of water for irrigation purposes was abundant.

The heavy rains from the 20th to 27th, and especially those of the 24th and 26th, caused floods of unusual proportions in the rivers and streams of portions of northern and eastern Georgia, northern South Carolina, and central and eastern North Carolina. Many of the streams reached heights previously unknown, and much loss of life and damage to property resulted. A more detailed history of these floods appears in another part of the Review.

After the 17th there was a general absence of precipitation over portions of the Ohio Valley and Lake region, and by the end of the month the need of more rain was being felt in those districts.

HUMIDITY AND SUNSHINE.

Altho rainfall was unusually heavy and rainy days comparatively frequent during the month along the Atlantic coast, the relative humidity was generally less than the average and it was also below average over practically all other districts east of the Mississippi River. From the Mississippi River westward to the Pacific there was a uniform excess of humidity, except at a few points in central California. Over most of the Mountain and Plateau districts the excess ranged from 10 to 15 per cent.

There was an abundance of sunshine over the districts from the Appalachain Mountains westward over the Ohio, Mississippi, and Missouri valleys, over the Gulf States and generally over the Pacific slope. There was much cloudy, rainy weather along the middle Atlantic coast, over southern New England and portions of Arizona and the central and southern parts of the Rocky Mountain region.

WEATHER IN ALASKA.

From the few reports received it appears that seasonable weather prevailed over that Territory. In the southern coast district temperatures were moderate and clear and rainy weather succeeded each other at frequent intervals, with rainfall from 3 to 5 inches. In the vicinity of Cook Inlet and at the mouth of the Copper River the minimum temperatures reached the freezing point toward the end of the month, and cloudy, rainy weather was the rule. Over the eastern interior districts embracing the upper Yukon Valley, temperatures near the freezing point occurred on several dates, there were but few days with rain and much calm, clear weather prevailed.

Average temperatures and departures from the normal.

Districts.	Number of stations.	Average temperatures for the current month.	Departures for the current month.	Accumulated departures since January 1.	Average departures since January 1.
		°	°	°	°
New England	12	66.5	— 0.9	+ 4.1	+ 0.5
Middle Atlantic	16	71.7	— 1.1	+ 1.1	+ 0.1
South Atlantic	10	77.9	+ 0.1	+ 8.3	+ 1.0
Florida Peninsula *	8	80.8	— 0.3	+ 7.2	+ 0.9
East Gulf	11	80.0	+ 0.8	+ 9.4	+ 1.2
West Gulf	10	81.2	+ 0.4	+13.1	+ 1.6
Ohio Valley and Tennessee	13	75.3	+ 0.5	+ 8.8	+ 1.1
Lower Lake	10	68.4	— 1.1	+ 1.8	+ 0.2
Upper Lake	12	66.4	+ 0.3	+10.3	+ 1.3
North Dakota *	9	63.4	— 3.2	+16.9	+ 2.1
Upper Mississippi Valley	15	72.2	— 0.6	+ 9.7	+ 1.2
Missouri Valley	12	72.7	— 1.1	+15.7	+ 2.0
Northern Slope	9	64.3	— 2.4	+ 6.7	+ 0.8
Middle Slope	6	74.5	— 0.8	+13.5	+ 1.7
Southern Slope *	7	78.7	— 0.8	+ 8.0	+ 1.0
Southern Plateau *	12	76.8	— 0.7	— 1.7	— 0.2
Middle Plateau *	10	68.3	— 1.3	— 3.4	— 0.4
Northern Plateau *	12	67.4	— 0.7	+ 4.6	+ 0.6
North Pacific	7	59.9	— 1.2	— 0.9	— 0.1
Middle Pacific	8	65.8	— 1.0	— 0.6	— 0.1
South Pacific	4	70.9	+ 0.4	+ 3.6	+ 0.4

* Regular Weather Bureau and selected cooperative stations.

Average precipitation and departures from the normal.

Districts.	Number of stations.	Average.		Departure.	
		Current month.	Percentage of normal.	Current month.	Accumulated since Jan. 1.
		Inches.		*Inches.*	*Inches.*
New England	12	4.55	115	+0.60	—2.60
Middle Atlantic	16	5.23	118	+0.80	—0.10
South Atlantic	10	9.02	147	+2.90	+1.50
Florida Peninsula *	8	7.43	103	+0.20	—4.50
East Gulf	11	3.71	79	—1.00	—0.50
West Gulf	10	3.40	113	+0.40	+1.60
Ohio Valley and Tennessee	13	3.05	88	—0.40	—1.20
Lower Lake	10	2.55	87	—0.40	+0.70
Upper Lake	12	2.89	97	—0.10	+0.30
North Dakota *	9	2.24	105	+0.10	+0.70
Upper Mississippi Valley	15	2.91	91	—0.30	+2.00
Missouri Valley	12	3.56	106	+0.20	+3.10
Northern Slope	9	1.45	117	+0.20	+2.50
Middle Slope	6	3.85	156	+1.40	+4.70
Southern Slope *	7	2.05	84	—0.40	+4.70
Southern Plateau *	12	1.79	120	+0.30	+0.80
Middle Plateau *	10	1.37	204	+0.70	+0.40
Northern Plateau *	12	0.54	100	0.00	—1.10
North Pacific	7	1.11	137	+0.30	—2.60
Middle Pacific	8	0.02	100	0.00	—3.90
South Pacific	4	0.18	257	+0.18	—1.12

* Regular Weather Bureau and selected cooperative stations.

In Canada.—Director R. F. Stupart says:

The temperature was from 1° to 2° above the average in the Lake Superior district and over a portion of the Georgian Bay region, but in all the large remaining portion of the Dominion the average was nowhere exceeded. The negative departures were small, however, and nowhere exceeded 3°; the greatest departures recorded were in northern British Columbia, northeastern Saskatchewan, in Manitoba, the Ottawa Valley, and the Bay of Fundy district.

In British Columbia the rainfall was slightly in excess of the average in Cariboo, but very deficient elsewhere. In Alberta it was everywhere less than the normal, as much as 50 per cent in some localities. In western Saskatchewan the rainfall was also sparse, but over the remainder of the Province and also in Manitoba rather more than the usual quantity was recorded. In Ontario it was more than the average over the larger portion of the Province, the exceptions to the prevailing conditions occurring in the Ottawa Valley and the eastern part, where little rain fell. In western Quebec the rainfall was also deficient, but in the middle and eastern portions of the Province the average quantity was well exceeded.

In the Maritime Provinces, except in a few isolated localities, the rainfall was greater than the average; this was especially the case in certain localities, noticeably in the vicinity of Halifax, where for the month it totalled nearly 11 inches, which is almost 6½ inches above the normal quantity.

Average relative humidity and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
New England	80	— 2	Missouri Valley	69	+ 2
Middle Atlantic	76	0	Northern Slope	60	+ 8
South Atlantic	83	+ 1	Middle Slope	66	+ 7
Florida Peninsula	82	+ 2	Southern Slope	69	+ 8
East Gulf	79	— 1	Southern Plateau	55	+13
West Gulf	78	+ 3	Middle Plateau	46	+15
Ohio Valley and Tennessee	71	— 1	Northern Plateau	44	+ 5
Lower Lake	69	— 2	North Pacific	75	+ 1
Upper Lake	73	— 2	Middle Pacific	60	— 1
North Dakota	64	— 2	South Pacific	66	0
Upper Mississippi Valley	70	0			

Average cloudiness and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
New England	5.2	+ 0.2	Missouri Valley	4.2	+ 0.1
Middle Atlantic	5.4	+ 0.4	Northern Slope	3.9	+ 0.2
South Atlantic	5.4	+ 0.2	Middle Slope	4.6	+ 0.8
Florida Peninsula	5.8	+ 0.6	Southern Slope	4.0	— 0.8
East Gulf	5.3	+ 0.4	Southern Plateau	3.6	+ 0.2
West Gulf	4.1	— 0.3	Middle Plateau	3.4	+ 1.2
Ohio Valley and Tennessee	4.6	+ 0.1	Northern Plateau	3.2	+ 0.2
Lower Lake	4.0	— 0.5	North Pacific	5.2	+ 1.3
Upper Lake	4.4	— 0.4	Middle Pacific	3.7	+ 0.9
North Dakota	3.7	— 0.2	South Pacific	2.1	— 0.4
Upper Mississippi Valley	4.2	+ 0.1			

Maximum wind velocities.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
Bismarck, N. Dak	10	68	nw.	Point Reyes Light, Cal.	24	56	nw.
Block Island, R. I	26	50	ne.	Do	27	55	nw.
Buffalo, N. Y	4	60	sw.	Do	28	76	nw.
Do	12	50	w.	Do	29	70	nw.
Jacksonville, Fla	20	53	s.	Southeast Faralon, Cal.	29	50	n.
La Salle, Ill	15	54	nw.	Toledo, Ohio	12	51	sw.
Mount Tamalpais, Cal	9	64	sw.	Topeka, Kans	26	51	nw.
Do	27	66	nw.	Valentine, Nebr	5	52	s.
Do	29	52	nw.	Williston, N. Dak.	25	67	w.
Nantucket, Mass	27	55	ne.				

CLIMATOLOGICAL SUMMARY.

By Mr. P. C. Day, Acting Chief, Climatological Division.

TEMPERATURE AND PRECIPITATION BY SECTIONS, AUGUST, 1908.

In the following table are given, for the various sections of the Climatological Service of the Weather Bureau, the average temperature and rainfall, the stations reporting the highest and lowest temperatures with dates of occurrence, the stations reporting greatest and least monthly precipitation, and other data, as indicated by the several headings.

The mean temperatures for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperature and precipitation are based only on records from stations that have ten or more years of observation. Of course the number of such records is smaller than the total number of stations.

Section.	Temperature—in degrees Fahrenheit.								Precipitation—in inches and hundredths.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
Alabama	79.4	0.0	Lock No. 4	104	16	Valley Head Albertville	52 52	10 11	3.44	− 1.56	Tuskegee	6.28	Highland Home	0.61
Arizona	80.8	− 1.0	Fort Mohave	119	7	Williams	41	29	2.49	+ 0.40	Bisbee	8.17	Fort Mohave	0.10
Arkansas	79.3	− 0.4	Lewisville McNeil	103 103	6 16	Bergman	52	26	4.48	+ 1.40	Alicia	8.50	Prescott	1.14
California	73.3	+ 0.3	Orland	120	7	Alturas	24	31	0.12	+ 0.02	Cuyamaca	2.87	Many stations	0.00
Colorado	64.4	− 1.7	Las Animas	106	5	Lay	19	31	2.50	+ 0.87	Santa Clara	6.77	Wagon Wheel Gap	0.26
Florida	81.1	− 0.3	Mariana	103	16	Molino	61	31	6.67	− 0.75	Arcadia	18.24	Macclenny	1.11
Georgia	79.0	− 0.2	Helena	105	18	Clayton Point Peter	54 54	31 30	6.04	+ 0.30	Carlton	20.18	Harrison	1.54
Hawaii														
Idaho	64.9	− 1.7	Orofino	110	1	Vanwyck	18	31	0.72	+ 0.19	Paris	2.00	Nevins Ranch	0.00
Illinois	73.9	+ 0.2	Mount Vernon	104	17	Lanark	38	24	2.47	− 0.68	La Grange	7.75	Streator	0.41
Indiana	73.9	+ 0.8	Zelma	104	2	3 stations	42	3 d't's	1.93	− 1.44	Columbus	5.06	Northfield	0.50
Iowa	70.0	− 1.8	Oskaloosa Ottumwa	101 101	3 3	Atlantic	38	24	4.77	+ 0.78	Pella	10.58	Rock Rapids	1.35
Kansas	76.2	− 0.9	Liberal	108	10	3 stations	43	20, 31	4.00	+ 0.92	Frankfort	11.48	Coolidge, Liberal	0.65
Kentucky	76.3	0.0	Catlettsburg	104	3	Shelby City	49	28	2.79	− 0.46	Beaverdam	5.27	Falmouth	0.07
Louisiana	81.3	− 0.2	Opelousas	104	13	4 stations	60	1, 31	6.61	+ 1.88	Lawrence	14.80	Plain Dealing	2.18
Maryland and Delaware	71.7	− 1.6	Green Sp'g Fur., Md.	101	4	Deer Park, Md	34	20	4.99	+ 0.74	Cheltenham, Md	10.61	Chewsville, Md.	1.98
Michigan	66.4	− 0.2	Pontiac	101	3	3 stations	29	24	3.01	+ 0.59	Olivet	8.62	Charlevoix	0.26
Minnesota	65.5	− 1.3	Alexandria	99	2	Angus	29	22, 23	2.06	− 1.54	Hallock	7.56	Farmington	0.39
Mississippi	80.0	− 0.5	Duck Hill	102	17	Lake Como Waynesboro	58 58	30 30	5.84	+ 1.26	Fayette	14.14	Batesville	1.56
Missouri	76.4	+ 0.1	Warsaw Jefferson City	102 102	5 15	Linneus Louisiana	46 46	21 26	3.87	+ 0.17	Maryville	7.28	St. Charles	0.78
Montana	62.4	− 1.2	Chinook Valentine	109 109	1 1	Grayling	17	26	1.08	− 0.05	Great Falls	3.13	Harlowton	T.
Nebraska	70.5	− 2.4	Cambridge	105	5	Fort Robinson	31	31	3.60	+ 0.66	Bluehill	8.49	Bridgeport	0.89
Nevada	69.7	− 0.3	Logan	108	7	Geyser	18	17	0.36	− 0.22	Las Vegas	1.35	7 stations	0.00
New England*	65.8	− 1.1	Torrington, Conn	98	13	5 stations	32	28, 29	4.91	+ 1.28	Norwalk, Conn	11.38	Burlington, Vt	1.70
New Jersey	70.6	− 1.8	Browns Mills	103	4	Layton	36	21	5.05	+ 0.28	Freehold	9.23	Layton	2.43
New Mexico	69.8	− 1.8	Orange	106	12	4 stations	37	8 d't's	3.38	+ 1.11	Las Vegas	9.24	Luna	0.70
New York	66.5	− 0.6	Port Jervis	100	4	Bensons Mines New Lisbon	32 32	20, 25 21	2.81	− 1.03	Bedford	7.99	Fayetteville	0.89
North Carolina	75.2	− 1.3	Selma Lexington	100 100	12 17	Banners Elk	42	30	10.18	+ 4.53	Monroe	19.38	Waynesville	3.74
North Dakota	63.2	− 2.9	Beach Mott	104 104	1 1	Napoleon	25	22	2.28	+ 0.69	Valley City	4.86	Buford	0.54
Ohio	71.2	− 0.5	Jacksonburg	104	3	Garrettsville Orangeville	37 37	21 21	2.59	− 0.57	Toledo	7.63	New Richmond	0.58
Oklahoma	79.8	− 0.9	Buffalo	107	10	Buffalo	46	9	2.18	− 0.78	Wagoner	5.65	Ardmore	0.41
Oregon	65.3	0.0	Unity, Baker Co	106	1	Christmas Lake	15	30	0.84	+ 0.24	Glenora	3.18	3 stations	0.00
Pennsylvania	69.4	− 0.8	Hanover	102	4	Dushore	30	21	3.22	− 1.38	Forks of Neshaminy	8.06	Saegerstown	1.22
Porto Rico	79.4	....	Manati	98	20	Las Marias	59	21	5.51	....	Maricao	13.27	Santa Isabel	0.77
South Carolina	78.6	− 0.5	5 stations	100	6 d't's	Trenton	49	29	9.11	+ 4.91	Greenville	19.52	Yemassee	3.16
South Dakota	67.8	− 2.6	Cherry Creek Howell	107 107	1 2	3 stations	32	22	2.19	− 0.29	Greenwood	4.69	Cascade Springs	0.27
Tennessee	76.6	+ 0.1	Carthage Lewisburg	100 100	17 18	Rugby	46	2	4.40	+ 0.73	Tellico Plains	10.35	Carthage	1.29
Texas	81.4	− 0.8	Fairland Henrietta	108 108	2 19	Plemons	49	8	3.00	+ 0.42	Kaufman	16.07	Chillicothe	T.
Utah	68.1	− 2.3	Green River	109	4	Richfield	22	31	1.20	+ 0.39	Pinto	3.45	Lucin, Castle Dale	T.
Virginia	72.1	− 2.1	Lincoln	100	4	Rocky Mount	40	26	6.38	+ 1.85	Petersburg	11.68	Brist l	3.05
Washington	65.1	− 1.1	Zindel	107	17	Wilbur	25	26	1.10	+ 0.28	Quiniault	4.40	3 stations	T.
West Virginia	70.9	− 1.7	Moorfield	101	4	Bayard	37	21	2.82	− 1.30	Creston	5.63	Huntington	0.84
Wisconsin	67.0	− 0.6	Sauk City	102	3	Long Lake	28	24	1.83	− 1.49	Portage	4.26	New Richmond	0.79
Wyoming	60.4	− 2.7	Basin	110	1	Riverside, Y. N. P	15	27, 31	1.88	+ 0.76	Soda Butte, Y. N. P	4.74	Gillette	0.54

* Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.

DESCRIPTION OF TABLES AND CHARTS.

By Mr. P. C. Day, Acting Chief, Climatological Division.

For description of tables and charts see page 8 of Review for January, 1908.

TABLE I.—*Climatological data for U. S. Weather Bureau stations, August, 1908.*

Stations.	Elevation of instruments.			Pressure, in inches.			Temperature of the air, in degrees Fahrenheit.									Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
	Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.					
New England.							**66.5**	**− 0.9**										**80**	**4.55**	**+ 0.6**										**5.2**	
Eastport	76	69	85	29.92	30.00	+ .04	60.8	+ 1.1	82	14	69	48	28	53	27	56	53	79	3.32	+ 0.1	12	6,455	s.	31	se.	6	9	11	11	5.9	
Greenville	1,070	6	....	28.86	30.02	......	60.0	......	80	12	71	33	29	49	40	....	....	....	7.96	......	10	......	......	....	......	....	....	....	....	....	
Portland, Me.	103	81	117	29.90	30.02	+ .04	65.4	− 0.8	82	14	73	46	29	58	29	60	56	76	3.73	+ 0.2	12	6,206	s.	28	s.	5	13	5	13	5.3	
Concord	288	70	79	29.71	30.02	+ .04	65.2	− 1.4	90	13	76	39	29	55	37	....	....	....	5.58	+ 1.8	10	3,121	nw.	27	w.	13	21	5	5	3.3	
Burlington	404	12	47	29.57	30.00	+ .03	66.0	− 2.7	84	6	76	44	25	56	31	....	....	....	1.70	− 2.3	12	6,806	s.	39	se.	4	9	15	7	5.0	
Northfield	876	16	70	29.10	30.03	+ .05	61.8	− 1.1	86	13	74	37	28	50	36	59	58	89	3.73	− 0.2	14	5,023	s.	28	se.	5	9	13	9	5.5	
Boston	125	115	188	29.89	30.02	+ .03	69.4	+ 0.5	90	14	76	47	29	63	25	63	59	73	4.35	+ 0.3	9	7,013	sw.	28	ne.	27	10	10	11	5.8	
Nantucket	12	14	90	30.00	30.01	+ .02	67.0	− 1.0	81	18	73	54	17	61	19	64	63	89	4.28	+ 1.2	12	10,973	sw.	55	ne.	27	11	7	13	5.8	
Block Island	26	11	46	29.99	30.02	+ .03	67.6	− 1.1	84	14	73	55	26	62	15	64	62	84	3.34	− 1.1	8	10,527	sw.	50	ne.	26	13	9	9	5.0	
Narragansett	....	9	....	......	......	......	67.4	− 1.1	86	14	74	47	21	60	27	....	....	....	7.27	......	10	......	sw.	....	......	....	17	3	11	....	
Providence	160	57	67	29.87	30.04	+ .05	68.4	− 2.6	89	14	77	47	29	60	27	62	59	76	5.16	+ 1.1	10	4,326	w.	22	ne.	27	16	7	8	4.8	
Hartford	159	122	132	29.86	30.03	+ .04	69.0	+ 0.1	88	13	78	43	29	60	31	63	61	81	6.74	+ 2.2	9	4,506	s.	30	sw.	5	9	11	11	6.1	
New Haven	106	116	155	29.91	30.02	+ .03	69.6	− 0.5	91	14	78	45	29	61	27	63	60	76	8.12	+ 3.1	11	6,153	n.	48	sw.	5	16	7	8	4.8	
Mid. Atlantic States.							**71.7**	**− 1.1**										**76**	**5.23**	**+ 0.8**										**5.4**	
Albany	97	102	115	29.92	30.02	+ .04	69.6	+ 0.1	93	13	79	48	28	60	29	62	58	71	3.63	− 0.3	9	4,800	s.	28	sw.	17	11	15	5	4.8	
Binghamton	871	78	90	29.12	30.04	+ .05	66.4	− 1.1	95	4	78	40	28	54	38	....	....	....	1.29	− 2.1	10	3,423	n.	34	sw.	13	6	15	10	5.7	
New York	314	108	350	29.69	30.01	+ .01	72.5	+ 0.3	91	4	79	56	27	66	20	65	61	71	5.65	+ 1.1	10	7,139	s.	37	ne.	26	12	10	9	5.3	
Harrisburg	374	94	104	29.64	30.03	+ .02	71.4	− 0.7	93	4	80	50	21	62	29	63	59	69	2.43	− 1.8	10	3,760	se.	36	w.	6	11	12	8	5.0	
Philadelphia	117	116	184	29.91	30.03	+ .03	73.4	− 0.4	94	4	80	56	26	66	24	65	61	71	5.41	+ 0.8	11	6,441	s.	31	n.	1	10	10	11	5.3	
Scranton	805	111	119	29.18	30.03	+ .03	68.6	− 0.7	95	4	80	43	21	57	36	61	57	72	3.44	− 0.8	10	4,391	ne.	26	sw.	5	11	12	8	4.6	
Atlantic City	52	37	48	29.97	30.03	+ .03	71.0	− 1.6	87	18	76	54	30	66	23	66	64	79	4.33	0.0	11	6,036	ne.	32	ne.	26	9	8	14	6.2	
Cape May	17	48	52	30.02	30.04	+ .04	70.8	− 2.6	83	18	76	52	29	66	17	67	....	....	5.03	+ 0.8	15	5,404	ne.	29	ne.	26	11	9	11	5.2	
Baltimore	123	100	113	29.88	30.01	.00	74.2	− 0.5	95	4	82	55	29	66	23	66	63	71	5.17	+ 1.0	10	4,903	sw.	27	n.	1	10	8	13	5.7	
Washington	112	59	76	29.90	30.02	+ .01	73.2	− 1.3	95	4	82	52	30	64	30	67	65	79	5.14	+ 0.7	9	4,180	n.	30	nw.	5	11	6	14	5.6	
Cape Henry	18	9	58	30.00	30.02	+ .02	76.7	− 0.2	92	13	82	64	28	71	21	....	....	....	6.01	− 0.1	14	10,271	sw.	46	ne.	1	9	9	13	5.6	
Lynchburg	681	83	88	29.31	30.04	+ .02	73.4	− 1.4	97	4	83	50	30	64	31	67	65	80	6.55	+ 2.3	12	2,269	ne.	16	nw.	1	9	13	9	5.5	
Mount Weather	1,725	10	54	28.25	30.02	+ .01	68.2	− 1.2	89	4	75	50	25	62	18	62	59	78	7.40	+ 3.8	10	6,885	nw.	41	nw.	6	9	9	13	5.8	
Norfolk	91	102	111	29.92	30.02	+ .02	76.1	− 0.6	93	15	82	63	28	70	20	71	69	83	8.00	+ 2.0	13	6,191	s.	26	w.	15	8	9	14	6.2	
Richmond	144	145	153	29.88	30.02	+ .01	74.0	− 3.5	95	14	82	55	30	66	25	....	....	....	10.40	+ 6.0	14	5,263	s.	36	nw.	19	12	8	11	5.1	
Wytheville	2,293	40	47	27.92	30.04	+ .03	68.4	− 2.1	90	3	78	48	31	59	35	64	64	94	3.74	− 0.8	18	2,30[illegible]	e.	13	nw.	1	11	10	10	5.3	
S. Atlantic States.							**77.9**	**+ 0.1**										**83**	**9.02**	**+ 2.9**										**5.4**	
Asheville	2,255	53	75	27.73	30.02	.00	71.4	+ 0.9	89	18	81	54	28	62	28	65	64	88	7.44	+ 2.6	14	3,850	se.	26	e.	3	4	16	11	6.4	
Charlotte	773	68	76	29.22	30.04	+ .02	75.6	− 0.1	95	4	84	56	30	67	28	69	67	83	14.61	+ 9.1	16	3,871	ne.	30	n.	18	10	9	12	5.8	
Hatteras	11	12	47	30.00	30.01	+ .01	78.8	+ 0.6	88	17	84	69	11	74	15	75	74	86	14.93	+ 9.1	15	9,996	sw.	49	nw.	1	18	10	3	3.8	
Manteo	....	....	....	......	......	......	77.6	......	89	18	83	67	2	72	....	....	....	....	13.64	+ 7.7	12	......	s.	....	......	....	....	....	....	....	
Raleigh	376	71	79	29.63	30.01	.00	75.0	− 1.8	94	15	83	57	31	67	22	69	68	84	13.63	+ 7.7	12	4,885	ne.	34	nw.	19	11	7	13	5.7	
Wilmington	78	81	91	29.94	30.02	+ .02	78.4	+ 0.8	92	8	86	63	27	71	20	73	72	84	9.52	+ 3.0	15	5,441	sw.	30	e.	18	9	15	7	5.4	
Charleston	48	14	92	29.96	30.01	.00	80.4	+ 0.1	95	1	86	66	28	74	19	74	72	79	4.88	− 2.1	12	7,213	s.	35	sw.	25	13	16	2	4.5	
Columbia, S. C.	351	41	57	29.63	30.01	.00	79.0	− 0.5	96	3	88	59	30	70	26	71	68	78	7.65	+ 0.9	9	4,381	s.	24	w.	8	5	11	15	6.5	
Augusta	180	89	97	29.81	30.00	− .01	79.4	+ 0.5	96	14	88	58	30	70	26	72	70	80	5.91	+ 0.3	13	3,924	s.	34	sw.	2	10	11	10	5.4	
Savannah	65	81	89	29.94	30.01	.00	80.2	+ 0.8	95	1	87	65	29	73	19	73	71	82	4.13	− 3.4	15	4,898	sw.	28	n.	2	9	13	9	5.5	
Jacksonville	43	101	129	29.96	30.02	+ .01	80.4	+ 0.3	95	2	87	68	29	74	18	75	74	86	2.90	− 3.3	12	7,102	sw.	53	s.	20	11	13	7	5.0	
Florida Peninsula.							**81.3**	**− 0.5**										**82**	**7.29**	**+ 1.4**										**5.8**	
Jupiter	28	10	48	29.98	30.01	+ .01	80.4	− 1.1	90	20	87	70	26	74	18	76	74	85	9.20	+ 3.4	22	5,802	sw.	36	e.	14	3	21	7	5.8	
Key West	22	10	53	29.98	30.00	+ .02	82.2	− 1.6	91	25	89	71	28	76	19	76	74	78	7.74	+ 3.0	16	4,539	s.	40	w.	27	4	18	9	6.2	
Sand Key	25	41	71	29.96	29.99	+ .01	82.2	......	94	8	87	68	13	78	18	....	....	....	4.76	+ 0.1	16	7,103	se.	47	e.	13	3	22	6	5.7	
Tampa	35	79	96	29.98	30.01	+ .01	81.2	+ 1.2	96	2	89	68	27	73	28	75	73	82	7.48	− 1.1	20	4,948	ne.	26	s.	26	7	17	7	5.4	
East Gulf States.							**80.0**	**+ 0.8**										**79**	**3.71**	**− 1.0**										**5.3**	
Atlanta	1,174	190	216	28.80	30.01	.00	77.2	+ 1.1	96	15	86	60	30	68	24	69	67	79	5.44	+ 1.0	12	5,574	se.	40	nw.	8	9	8	14	5.9	
Macon	370	78	87	29.61	30.00	− .01	79.6	+ 1.4	96	15	89	61	31	70	26	....	....	....	6.12	+ 1.9	12	3,438	ne.	26	nw.	7	10	12	9	5.3	
Thomasville	273	8	58	29.71	30.00	.00	80.4	− 0.6	97	3	90	61	11	70	31	73	72	84	3.03	− 2.0	12	3,283	se.	21	sw.	21	5	18	8	5.7	
Pensacola	56	79	96	29.94	30.00	+ .02	81.0	0.0	93	15	87	69	29	75	18	....	....	....	3.66	− 3.5	6	6,266	sw.	36	w.	22	13	9	9	4.8	
Anniston	741	9	58	29.25	30.03	+ .04	78.3	+ 1.9	98	16	89	58	10	68	31	....	....	....	1.99	− 2.5	13	2,825	se.	21	w.	17	8	10	13	6.2	
Birmingham	700	11	48	29.26	30.02	+ .03	79.6	− 0.2	98	16	89	61	10	70	26	71	68	78	1.06	− 3.4	10	3,376	n.	35	nw.	8	2	21	8	6.3	
Mobile	57	98	106	29.93	29.99	+ .01	81.9	+ 2.2	96	15	90	67	10	74	20	74	71	77	3.91	− 2.9	12	4,547	s.	22	se.	2	13	16	2	4.2	
Montgomery	223	100	112	29.75	30.00	+ .01	80.2	+ 0.5	98	16	90	62	29	71	26	71	68	74	2.72	− 1.5	7	3,689	w.	48	s.	7	7	13	11	5.8	
Meridian	375	84	93	29.61	29.99	+ .01	78.8	+ 0.3	95	16	88	60	10	70	25	71	69	80	3.53	0.0	9	3,030	sw.	21	n.	8	17	11	3	4.0	
Vicksburg	247	62	74	29.72	29.99	+ .01	80.2	+ 0.6	96	17	88	67	9	72	22	73	71	81	3.71	+ 0.2	8	3,314	n.	25	nw.	8	12	11	8	4.7	
New Orleans	51	88	121	29.94	29.98	.00	82.5	+ 1.5	94	15	89	73	30	76	16	75	73	81	5.65	0.0	17	4,931	s.	27	se.	6	7	20	4	5.2	
West Gulf States.							**81.2**	**+ 0.4**										**78**	**3.40**	**+ 0.4**										**4.6**	
Shreveport	249	77	84	29.72	29.98	+ .01	81.6	+ 0.2	96	16	90	68	31	73	23	73	70	78	3.07	+ 0.8	10	3,626	se.	27	ne.	1	17	8	6	3.8	
Bentonville	1,303	11	44	28.65	29.98	+ .01	77.0	+ 0.5	95	6	88	56	9	66	31	....	....	....	3.94	− 0.1	7	2,962	s.	20	s.	11	18	9	4	3.6	
Fort Smith	457	79	94	29.49	29.96	− .01	80.1	+ 0.7	97	6	90	63	9	70	27	72	69	79	7.32	+ 3.7	9	4,024	e.	26	e.	2	17	8	6	3.6	
Little Rock	357	139	147	29.62	29.99	+ .01	80.0	+ 0.8	95	17	88	67	26	72	23	72	70	78	2.58	− 1.1	10	4,673	e.	30	nw.	18	11	12	8	4.8	
Corpus Christi	20	48	53	29.94	29.96	+ .03	83.0	+ 0.9	95	1	89	70	20	77	18	76	74	81	1.55	− 0.7	8	7,227	se.	31	se.	11	15	14	2	3.6	
Fort Worth	670	106	114	29.28	29.98	+ .04	82.2	− 0.7	100	7	92	62	9	72	31	....	....	....	2.74	+ 0.9	5	5,155	s.	36	ne.	17	14	16	1	3.5	
Galveston	54	106	112	29.94	30.00	+ .04	83.1	+ 0.5	91	25	87	72	21	79	12	76	74	78	4.16	− 0.8	8	6,527	s.	26	n.	1	15	11	5	4.3	
Palestine	510	73	79	29.44	29.96	− .01	80.7	+ 0.2	95	16	90	68	10	72	25	72	70	77	2.69	+ 0.5	7	2,488	s.	30	sw.	22	8	13	10	5.6	
San Antonio	701	80	91	29.23	29.94	+ .01	82.7	+ 0.7	99	2	93	68	17	72	27	72	69	75	4.27	+ 1.6	10	3,960	se.	36	nw.	8	7	19	5	5.0	
Taylor	583	55	63	29.37	29.98	+ .03	81.7	0.0	96	10	92	65	10	71	31	....	....	....	1.67	− 0.8	10	4,954	s.	33	sw.	16	19	7	5	3.6	
Ohio Val. and Tenn.							**75.3**	**+ 0.5**										**71**	**3.05**	**− 0.4**										**4.6**	
Chattanooga	762	106	112	29.23	30.02	+ .02	77.2	+ 0.7	94	15	86	61	10	68	25	70	67	77	7.04	+ 3.3	13	3,301	sw.	31	nw.	19	8	13	10	5.6	
Knoxville	1,004	93	100	28.98	30.01	.00	75.8	+ 1.1	93	17	85	59	10	67	26	68	66	78	3.95	0.0	10	2,696	ne.	20	se.	3	4	14	13	6.5	
Memphis	399	76	97	29.59	30.01	+ .03	79.4	+ 0.2	93	16	87	66	25	72	19	72	70	79	4.52	+ 1.3	8	4,535	n.	32	nw.	7	14	7	10	4.8	
Nashville	546	79	91	29.44	30.01	+ .01	78.6	+ 0.8	96	17	88	60	9	69	28	71	68	76	1.69	− 1.8	9	3,016	n.	25	n.	31	11	12	8	4.9	
Lexington	989	75	102	28.98	30.02	+ .01	74.6	0.0	93	3	84	55	28	65	28	....	....	....	2.98	− 0.6	6	5,295	ne.	24	n.	21	17	11	3	3.4	
Louisville	525	111	132	29.45	30.02	+ .02	78.2	+ 1.9	98	16	89	60	10	68	30	67	62	65	2.29	− 1.2	6	4,388	n.	28	nw.	17	14	12	5	3.9	
Evansville	431	72	82	29.53	29.99	.00	78.0	+ 1.0	94	2	87	61	10	69	29	....	....	....	4.58	+ 1.3	7	4,339	s.	25	w.	10	14	15	2	4.0	
Indianapolis	822	154	164	29.14	30.01	+ .01	74.6	+ 1.0	95	16	85	55	23	64	30	64	59	62	1.67	− 1.7	3	5,519	ne.	38	sw.	12	11	16	4	5.0	
Cincinnati	628	152	160	29.35	30.01	.00	76.6	+ 1.1	98	16	87	58	25	66	31	65	58	58	1.69	− 1.6	6	4,044	ne.	32	nw.	17	13	15	3	4.1	
Columbus	824	173	224	29.17	30.03	+ .02	72.7	− 0.3	95	3	84	55	25	62	30	63	58	66	2.34	− 0.9	7	6,764	e.	44	w.	17	17	12	2	3.3	
Pittsburg	842	336	352	29.14	30.03	+ .02	71.6	− 0.9	94	4	81	53	21	62	30	62	57	64	2.48	− 0.7	9	5,516	ne.	36	w.	4	11	17	3	4.6	
Parkersburg	638	77	84	29.38	30.04	+ .03	73.4	+ 0.1	98	17	85	54	21	62	34	64	60	71	1.88	− 1.6	8	3,307	sw.	22	n.	17	16	12	3	4.0	
Elkins	1,940	41	50	28.05	30.05	+ .03	67.8	− 0.6	92	4	80	44	21	56	39	62	60	85	2.60	− 1.0	12	1,914	n.	22	w.	4	10	12	9	5.4	
Lower Lake Region.							**68.4**	**− 1.1**										**69**	**2.55**	**− 0.4**										**4.4**	
Buffalo	767	178	206	29.20	30.02	+ .03	67.7	− 1.1	86	4	75	48	25	60	24	62	58	72	2.85	− 0.1	9	7,732	sw.	60	sw.	4	13	11	7	4.6	
Canton	448	10	71	29.54	30.00	......	65.0	− 2.8	85	31	76	40	25	54	35	....	....	....	1.01	− 1.7	9	6,765	sw.	38	w.	19	14	11	6	4.3	
Oswego	335	76	91	29.64	30.01	+ .02	67.4	− 1.4	88	4	75	51	21	60	27	62	58	73	1.62	− 1.1	7	5,942	s.	32	ne.	1	14	12	5	4.1	
Rochester	523	81	102	29.47	30.02	+ .04	68.1	− 0.2	91	4	78	48	25	58	31	60	55	68	1.18	− 1.8	5	4,907	sw.	34	w.	12	15	11	5	4.4	
Syracuse	597	97	113	29.39	30.03	+ .04	67.6	− 1.0	92	4	77	46	25	58	29	....	....	....	0.66	− 2.7	7	6,711	s.	33	s.	4	10	13	8	4.8	
Erie	713	92	102	29.26	30.02	+ .01	68.2	− 1.7	90	4	76	49	21	61	26	61	56	64	1.32	− 1.9	9	6,461	s.	28	sw.	4	15	8	8	4.1	
Cleveland	762	190	201	29.22	30.02	+ .01	68.9	− 1.5	91	3	76	50	21	61	24	61	56	65	1.75	− 1.4	9	9,110	se.	38	n.	12	17	11	3	3.5	
Sandusky	629	62	70	29.35	30.02	+ .01	70.7	− 0.8	95	3	79	52	21	62	27	....	....	....	2.96	− 0.4	8	5,390	ne.	30	nw.	4	18	9	4	3.1	
Toledo	628	207	246	29.36	30.03	+ .03	70.6	− 0.3	94	3	80	50	20	61	28	62	58	68	7.63	+ 4.9	10	8,317	sw.	51	sw.	12	20	6	5	2.7	
Detroit	730	218	258	29.25	30.03	+ .02	69.7	− 0.2	95	3	79	50	20	60	29	62	59	72	4.49	+ 1.7	10	8,643	s.	44	sw.	12	14	13	4	4.2	
Upper Lake Region.							**66.4**	**+ 0.3**										**73**	**2.89**	**− 0.1**										**4.4**	
Alpena	609	13	92	29.36	30.02	+ .02	64.0	+ 0.2	88	3	75	40	25	53	33	59	56	78	1.87	− 1.5	7	7,050	nw.	30	se.	12	13	12	6	4.6	

TABLE I.—*Climatological data for U. S. Weather Bureau stations, August, 1908*—Continued.

Stations.	Elevation of instruments: Barometer above sea level, feet.	Elevation of instruments: Thermometers above ground.	Elevation of instruments: Anemometer above ground.	Pressure, in inches: Actual, reduced to mean of 24 hours.	Pressure, in inches: Sea level, reduced to mean of 24 hrs.	Pressure, in inches: Departure from normal.	Temperature: Mean max. + mean min. ÷ 2.	Temperature: Departure from normal.	Temperature: Maximum.	Temperature: Date.	Temperature: Mean maximum.	Temperature: Minimum.	Temperature: Date.	Temperature: Mean minimum.	Temperature: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation: Total.	Precipitation: Departure from normal.	Precipitation: Days with .01, or more.	Wind: Total movement, miles.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
Up. Lake Reg.—Cont.																															
Escanaba	612	40	82	29.35	30.00	+ .01	64.2	− 0.3	86	4	73	41	24	55	33	59	56	77	1.06	− 2.6	10	6,492	s.	27	nw.	21	11	11	9	4.8	
Grand Haven	632	54	92	29.34	30.00	+ .01	66.4	− 1.4	86	3	76	45	26	57	31	62	58	76	5.78	+ 3.2	8	6,430	sw.	33	nw.	3	20	9	2	3.1	
Grand Rapids	707	121	162	28.26	30.02	+ .02	69.1	− 0.9	93	3	80	46	20	58	28	60	56	67	5.55	+ 3.0	9	6,187	w.	48	w.	3	14	13	4	4.2	
Houghton	668	66	74	29.26	29.98	+ .01	64.0	+ 0.7	90	30	73	43	24	55	32	....	....	....	1.00	− 1.9	7	5,154	w.	30	nw.	1	12	12	7	1.6	
Marquette	734	77	116	29.20	30.00	+ .02	65.0	+ 1.5	93	31	74	47	24	56	32	57	52	68	1.08	− 1.8	6	7,695	w.	36	s.	31	11	12	8	4.8	
Port Huron	638	70	120	29.33	30.02	+ .02	67.4	+ 0.1	95	3	77	45	20	58	29	61	58	73	4.80	+ 2.2	7	6,667	ne.	37	w.	12	15	11	5	4.3	
Sault Sainte Marie	614	40	61	29.32	30.01	+ .02	62.3	+ 1.7	89	31	71	42	25	54	27	57	54	79	2.29	− 0.8	7	5,691	nw.	32	nw.	19	10	10	11	5.5	
Chicago	823	140	310	29.15	30.02	+ .02	73.4	+ 2.2	96	3	80	58	23	67	23	65	60	67	6.35	+ 3.5	8	9,089	ne.	49	sw.	12	17	11	3	3.6	
Milwaukee	681	122	139	29.30	30.04	+ .04	70.2	+ 1.5	95	3	78	53	24	63	26	62	58	70	1.63	− 1.2	9	6,995	se.	42	nw.	16	19	10	2	3.0	
Green Bay	617	49	86	29.33	29.99	.00	68.6	+ 1.6	91	31	79	44	20	58	30	60	56	70	1.19	− 1.9	5	6,563	sw.	36	n.	19	8	16	7	5.8	
Duluth	1,133	11	47	28.78	29.99	+ .02	62.1	− 2.8	83	3	71	43	22	53	27	57	54	80	2.10	− 1.4	8	8,789	ne.	45	nw.	18	8	19	4	4.9	
North Dakota.							63.9	− 2.8										64	2.06	− 0.2										3.7	
Moorhead	940	8	57	28.97	29.98	+ .02	65.1	− 0.8	96	2	78	38	22	52	38	57	54	73	3.01	− 0.1	8	5,257	se.	40	nw.	29	18	9	4	3.0	
Bismarck	1,674	8	57	28.24	30.00	+ .06	65.2	− 2.9	100	1	79	35	22	51	44	55	48	62	2.44	+ 0.5	8	7,640	nw.	68	nw.	10	15	10	6	3.9	
Devils Lake	1,482	11	44	28.38	29.94	.00	62.4	− 2.7	90	20	76	32	22	49	42	54	48	64	1.70	− 1.1	8	8,167	w.	48	ne.	30	16	11	4	3.6	
Williston	1,875	14	56	27.99	29.94	+ .01	62.9	− 5.0	102	1	77	32	22	48	51	53	44	57	1.11	− 0.2	9	7,584	n.	67	w.	25	14	12	5	4.2	
Upper Miss. Valley.							72.2	− 0.6										70	2.91	− 0.3										4.2	
Minneapolis	......	102	208	......	......	......	69.0	......	92	2	79	46	22	59	27	....	....	....	0.62	− 3.1	8	7,768	se.	36	s.	30	16	10	5	4.1	
St. Paul	837	171	179	29.10	30.00	+ .03	68.4	− 1.1	90	2	78	46	22	59	28	60	54	67	1.07	− 2.4	6	6,435	se.	35	n.	21	15	14	2	3.4	
La Crosse	714	10	49	29.25	30.01	+ .03	68.8	− 1.2	93	2	80	46	23	57	31	....	....	....	1.76	− 1.6	6	3,043	s.	15	sw.	31	7	16	8	5.4	
Madison	974	70	78	28.98	30.01	+ .02	69.1	− 0.5	94	3	79	52	25	59	28	61	57	70	2.53	− 0.7	8	5,234	sw.	30	ne.	11	17	11	3	3.5	
Charles City	1,015	10	49	28.96	30.02	+ .05	67.4	− 3.3	90	2	79	43	24	56	33	62	59	78	3.48	+ 0.1	8	3,673	sw.	19	w.	15	7	17	7	5.2	
Davenport	606	71	79	29.36	30.01	+ .03	72.2	− 0.8	95	3	82	51	24	62	28	64	60	70	6.23	+ 2.6	9	3,896	sw.	26	nw.	11	16	9	6	4.0	
Des Moines	861	84	101	29.09	29.99	+ .02	71.4	− 1.6	95	3	81	52	24	62	29	64	60	70	6.54	+ 2.9	12	4,652	sw.	26	sw.	26	8	17	6	5.5	
Dubuque	698	100	117	29.28	30.02	+ .04	69.6	− 2.4	96	3	80	46	24	59	32	62	59	72	2.92	− 0.1	7	2,791	se.	20	nw.	28	13	12	6	4.1	
Keokuk	614	64	77	29.35	30.01	+ .03	74.5	− 0.1	95	16	85	54	25	64	31	65	62	70	2.50	− 0.7	5	3,633	s.	30	sw.	11	20	8	3	3.0	
Cairo	356	87	93	29.62	29.99	.00	78.2	+ 1.2	96	17	86	63	8	70	22	70	68	76	4.28	+ 1.4	10	4,746	n.	39	ne.	8	14	12	5	4.4	
La Salle	536	56	64	29.47	30.04	+ .05	72.2	+ 0.2	95	3	84	49	24	60	33	....	....	....	1.82	− 1.0	6	3,920	ne.	54	nw.	15	15	11	5	3.9	
Peoria	609	11	45	29.37	30.03	+ .04	72.6	+ 0.1	95	3	84	46	21	61	36	64	60	72	2.78	− 0.2	8	3,969	ne.	24	sw.	12	21	7	3	3.3	
Springfield, Ill.	644	10	92	29.33	30.00	+ .01	75.2	+ 1.2	97	16	86	54	25	64	35	65	60	64	2.62	− 0.2	6	4,793	sw.	31	w.	12	20	6	5	3.2	
Hannibal	534	75	109	29.44	30.00	+ .02	74.4	− 0.6	95	16	85	52	21	64	36	...	....	....	2.94	− 0.4	9	4,986	sw.	33	n.	28	15	8	8	4.3	
St. Louis	567	208	217	29.39	29.98	− .01	77.5	+ 0.3	98	16	86	59	26	69	23	68	63	66	1.55	− 1.1	7	5,770	ne.	31	nw.	5	10	10	11	5.5	
Missouri Valley.							72.7	− 1.1										69	3.56	+ 0.2										4.2	
Columbia, Mo.	784	11	84	29.18	29.99	+ .02	75.3	+ 0.6	97	15	87	55	25	64	34	....	....	....	4.74	+ 1.7	8	4,337	ne.	27	nw.	28	12	13	6	4.1	
Kansas City	963	116	181	28.97	29.97	.00	75.6	− 0.2	94	16	85	57	20	66	25	67	64	70	4.97	+ 0.2	12	7,637	s.	45	nw.	5	16	12	3	3.6	
Springfield, Mo.	1,324	98	104	28.62	29.99	+ .02	75.9	+ 1.1	93	6	85	58	8	67	25	68	65	77	3.66	− 0.6	9	5,430	s.	24	w.	19	24	6	1	1.8	
Iola	984	11	50	28.96	29.98	+ .02	77.6	+ 1.3	97	11	89	59	8	66	31	....	....	....	3.29	− 0.2	9	4,364	s.	36	ne.	26	13	10	8	4.9	
Topeka	......	85	89	......	......	......	75.8	− 0.2	96	4	86	57	20	66	26	....	....	....	7.76	+ 3.5	10	5,788	se.	51	nw.	26	15	14	2	3.4	
Lincoln	1,189	11	84	28.73	29.97	+ .02	73.2	− 1.1	96	3	84	50	20	63	31	65	62	72	2.84	− 0.9	11	6,259	s.	34	se.	26	13	12	6	4.8	
Omaha	1,105	115	121	28.83	29.98	+ .02	73.2	− 1.2	96	3	82	54	20	64	27	65	61	70	2.20	− 1.4	12	5,082	s.	38	n.	21	8	13	10	5.4	
Valentine	2,598	47	54	27.31	29.99	+ .05	68.6	− 2.7	100	2	82	43	28	56	45	59	54	66	1.97	− 0.8	13	7,114	s.	52	s.	5	13	16	2	3.8	
Sioux City	1,135	96	164	28.80	29.99	+ .04	69.8	− 2.8	96	3	80	45	20	59	35	....	....	....	4.28	+ 1.3	9	7,355	se.	40	nw.	15	13	10	8	4.5	
Pierre	1,572	70	75	28.33	29.97	+ .03	71.0	− 2.1	102	1	83	48	28	59	39	59	51	57	2.32	+ 0.3	4	7,141	se.	37	nw.	26	14	11	6	4.3	
Huron	1,306	56	67	28.62	30.00	+ .05	67.0	− 2.1	97	2	80	40	22	54	40	59	55	72	1.38	− 1.3	9	7,098	se.	38	s.	30	15	9	7	4.1	
Yankton	1,233	49	57	28.68	29.98	+ .03	69.0	− 3.8	94	2	80	47	20	58	35	....	....	....	3.34	+ 0.2	7	4,713	ne.	31	s.	30	12	9	10	5.4	
Northern Slope.							64.3	− 2.4										60	1.45	+ 0.2										3.9	
Havre	2,505	11	44	27.36	29.95	+ .04	65.3	− 1.6	106	1	79	42	15	51	44	55	48	60	0.85	− 0.4	9	5,839	nw.	38	sw.	26	19	11	1	3.4	
Miles City	2,371	26	48	27.48	29.99	+ .06	68.4	− 3.1	108	1	83	44	26	54	48	57	49	56	0.63	− 0.4	6	3,826	ne.	40	nw.	25	16	12	3	3.5	
Helena	4,110	8	56	25.85	29.99	+ .05	63.0	− 3.1	98	1	76	39	26	50	38	51	42	55	0.90	+ 0.2	2	4,972	sw.	30	w.	25	18	8	5	3.6	
Kalispell	2,962	8	34	26.94	29.95	+ .02	61.9	− 1.0	92	1	76	36	27	47	41	50	42	57	0.88	0.0	6	3,805	w.	21	s.	1	19	8	4	3.4	
Rapid City	3,234	46	50	26.64	29.99	+ .06	67.0	− 1.8	96	1	80	45	23	54	46	55	46	54	0.87	− 1.2	5	5,018	w.	36	nw.	25	20	4	7	3.2	
Cheyenne	6,088	56	64	24.12	29.98	+ .06	63.2	− 2.6	89	3	76	41	31	50	35	53	47	64	2.45	+ 1.0	15	5,568	s.	40	nw.	30	13	12	6	4.7	
Lander	5,372	26	36	24.72	29.98	+ .06	62.8	− 2.9	93	9	78	29	31	48	44	51	43	58	1.52	+ 1.0	9	2,565	sw.	28	sw.	15	17	9	5	3.7	
Sheridan	3,790	9	47	26.14	29.99	......	63.6	......	100	1	79	37	30	48	49	53	46	63	0.95	......	8	4,141	se.	48	nw.	25	15	9	7	4.2	
Yellowstone Park	6,200	11	48	23.99	30.02	+ .09	57.0	− 3.9	86	1	70	31	26	44	40	46	38	62	3.42	+ 2.4	15	4,486	sw.	44	nw.	9	11	6	14	5.2	T.
North Platte	2,821	11	51	27.11	29.99	+ .05	70.2	− 2.0	98	5	83	44	20	57	39	61	56	68	1.57	− 0.9	13	5,462	se.	42	n.	9	15	12	4	4.1	
Middle Slope.							74.5	− 0.8										66	3.85	+ 1.4										4.6	
Denver	5,291	129	136	24.81	29.97	+ .05	68.8	− 1.6	92	5	81	49	31	57	34	57	50	62	3.19	+ 1.8	15	4,656	s.	34	w.	13	9	15	7	5.2	
Leadville	10,248	7	......	......	......	......	......	......	......	......	......	......	......	......	......	....	....	....	......	......	......	......	......	......	......	......	......	......	......	......	
Pueblo	4,685	80	86	25.35	29.95	+ .04	71.4	− 0.7	96	5	84	54	21	58	38	57	49	56	1.67	+ 0.1	9	4,139	se.	36	n.	6	11	15	5	4.4	
Concordia	1,398	42	50	28.54	29.98	+ .03	74.4	− 2.1	98	4	85	53	20	64	35	67	64	75	8.56	+ 5.8	17	4,399	s.	36	sw.	28	6	25	0	5.1	
Dodge	2,509	44	54	27.39	29.93	.00	76.0	− 0.5	98	10	88	54	8	64	36	65	60	66	1.51	− 1.1	7	6,761	se.	33	se.	30	12	13	6	4.5	
Wichita	1,358	90	120	28.58	29.98	+ .03	77.1	− 0.4	99	11	88	58	8	66	32	67	63	68	6.57	+ 3.5	9	6,897	s.	33	sw.	27	14	13	4	4.3	
Oklahoma	1,214	10	47	28.70	29.95	+ .01	79.2	+ 0.7	97	17	90	58	9	68	31	69	66	72	1.59	− 1.6	7	8,551	s.	42	s.	11	13	15	3	4.0	
Southern Slope.							78.0	− 1.0										69	2.60	+ 0.4										4.0	
Abilene	1,738	45	54	28.18	29.94	+ .02	80.8	− 0.4	96	10	91	61	9	70	31	69	63	62	1.23	− 0.7	4	5,069	s.	24	s.	11	11	19	1	4.6	
Amarillo	3,676	10	49	26.31	29.96	+ .04	74.4	− 0.2	97	10	86	58	8	63	33	64	60	70	2.75	− 0.1	6	7,891	s.	36	s.	26	22	9	0	3.5	
Del Rio	944	8	57	28.95	29.91	+ .01	82.0	− 2.0	101	2	92	64	17	72	29	....	....	....	3.54	+ 0.8	7	5,142	se.	34	ne.	9	20	8	3	3.4	
Roswell	3,578	9	57	26.39	29.95	+ .07	75.2	− 1.4	95	11	87	60	10	63	35	66	62	74	2.87	+ 1.4	9	3,086	se.	27	nw.	19	11	17	3	4.5	
Southern Plateau.							76.6	− 0.8										55	1.93	+ 0.3										3.6	
El Paso	3,762	110	133	26.19	29.86	+ .02	77.6	− 1.0	96	12	89	61	15	67	28	64	58	59	2.55	+ 0.8	11	6,872	e.	47	ne.	13	13	17	1	4.1	
Santa Fe	7,013	33	39	23.36	29.90	+ .01	66.0	− 1.0	86	6	77	50	21	55	29	55	50	65	2.74	+ 0.4	15	4,737	se.	34	sw.	10	12	16	3	4.2	
Flagstaff	6,907	8	57	23.46	29.89	+ .05	62.8	− 0.2	84	7	75	44	19	50	34	54	51	75	4.69	+ 1.4	16	4,843	sw.	34	nw.	21	7	15	9	5.7	
Phoenix	1,108	50	56	28.69	29.80	+ .01	87.9	− 1.1	106	6	100	70	16	76	30	69	60	45	0.81	− 0.2	5	3,129	e.	36	nw.	2	11	19	1	4.0	
Yuma	141	9	58	29.64	29.78	+ .02	91.0	+ 0.9	110	1	104	65	28	78	41	74	66	51	0.30	0.0	3	5,105	s.	36	s.	8	28	2	1	1.0	
Independence	3,910	11	42	25.97	29.88	+ .07	74.2	− 2.2	98	8	90	48	31	58	38	56	41	35	0.46	+ 0.5	3	4,519	nw.	26	nw.	30	22	6	3	2.9	
Middle Plateau.							69.3	− 0.6										46	1.36	+ 0.7										3.4	
Reno	4,532	56	63	25.48	29.90	+ .06	68.9	+ 1.9	100	7	86	37	30	52	46	50	35	37	0.20	0.0	3	4,049	w.	27	s.	2	25	5	1	1.5	
Tonopah	6,089	12	20	24.13	29.93	......	70.9	+ 5.2	94	2	83	39	30	59	32	51	33	31	0.30	− 0.1	3	5,883	se.	37	se.	20	18	11	2	2.9	
Winnemucca	4,344	18	56	25.62	29.94	+ .06	68.4	− 2.4	100	8	87	36	30	50	48	51	39	41	0.04	− 0.1	1	3,394	ne.	28	sw.	27	20	7	4	2.6	
Modena	5,479	10	43	24.66	29.91	+ .05	67.4	− 1.2	92	4	82	41	31	53	39	56	50	60	2.76	+ 2.4	7	8,105	sw.	48	sw.	29	13	14	4	3.9	
Salt Lake City	4,366	105	110	25.63	29.92	+ .01	71.0	− 4.5	95	8	83	44	31	59	32	56	45	44	1.39	+ 0.6	9	4,509	se.	39	nw.	14	17	10	4	3.4	
Durango	6,546	18	56	23.76	29.93	+ .03	64.8	− 1.5	89	7	78	43	29	51	38	53	48	65	3.99	+ 2.2	17	3,622	nw.	24	ne.	7	1	22	8	5.9	
Grand Junction	4,608	43	51	25.40	29.92	+ .02	74.0	− 2.1	98	4	87	48	31	61	33	57	45	44	0.86	− 0.3	9	4,111	e.	33	nw.	11	20	8	3	3.3	
Northern Plateau.							69.7	− 0.7										44	0.59	+ 0.2										3.2	
Baker City	3,471	48	58	26.46	29.99	+ .04	65.0	+ 0.1	90	8	80	34	30	50	39	52	44	51	0.42	0.0	7	4,682	nw.	24	nw.	27	18	10	3	2.9	
Boise	2,739	78	86	27.14	29.94	+ .01	70.5	− 1.3	102	1	85	39	30	56	39	53	38	36	0.21	0.0	3	3,944	nw.	23	nw.	18	19	10	2	2.7	
Lewiston	757	10	51	29.14	29.94	− .01	73.5	0.0	102	17	88	46	31	58	43	....	....	....	1.03	+ 0.7	6	4,326	e.	48	w.	24	17	9	5	3.5	
Pocatello	4,477	46	54	25.52	29.96	+ .04	67.4	− 3.1	96	8	81	36	31	53	41	52	40	44	1.08	+ 0.5	8	5,863	se.	31	se.	13	17	13	1	3.0	
Spokane	1,929	101	110	27.94	29.95	.00	68.1	+ 0.2	96	19	82	42	31	54	42	52	39	43	0.57	+ 0.1	5	4,352	sw.	36	nw.	20	16	5	10	4.2	
Walla Walla	1,000	71	79	28.90	29.95	− .01	73.9	+ 0.1	100	17	85	48	26	62	35	59	48	47	0.22	− 0.2	4	4,102	s.	22	sw.	24	23	4	4	2.7	
N. Pac. Coast Reg.							59.0	− 1.2										75	1.11	+ 0.3										5.2	
Blaine	57	4	....	......	......	......	......	......	....	....	....	....	....	....	....	....	....	....	......	......	....	......	......	....	......	....	....	....	....	....	
North Head	211	11	56	29.86	30.08	+ .05	54.6	− 3.3	78	17	58	48	2	52	25	53	51	89	2.02	+ 1.5	6	9,985	nw.	48	se.	27	7	6	18	6.9	
Port Crescent	250	12	29	29.81	30.10	+ .08	54.2	− 2.0	86	17	60	42	2	48	35	....	....	....	1.24	+ 0.5	9	3,102	nw.	17	sw.	21	10	13	8	5.2	
Seattle	123	185	224	29.94	30.07	+ .07	62.2	− 0.9	88	18	71	46	31	54	28	56	52	73	0.82	+ 0.3	5	4,928	s.	30	s.	27	12	10	9	5.8	
Tacoma	218	113	120	29.81	30.03	+ .01	62.0	− 1.0	90	18	72	44	31	52	31	56	51	72	0.95	+ 0.2	4	3,378	n.	20	sw.	27	13	11	7	5.0	

TABLE I.—*Climatological data for U. S. Weather Bureau stations, August, 1908*—Continued.

Stations.	Elevation of instruments.			Pressure, in inches.			Temperature of the air, in degrees Fahrenheit.												Precipitation, in inches.			Wind.									
	Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Total.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
N. P. Coast Reg—Cont.																															
Tatoosh Island	86	7	57	29.97	30.06	+ .07	53.1	− 2.2	65	17	57	46	10	50	16	52	50	89	1.10	− 1.0	7	9,070	sw.	35	ne.	17	3	6	22	7.8	
Portland, Oreg	153	68	106	29.87	30.03	+ .02	66.0	+ 0.1	94	17	76	46	30	56	31	58	54	68	1.34	+ 0.7	6	4,361	nw.	21	nw.	8	16	10	5	3.7	
Roseburg	510	9	57	29.48	30.02	+ .02	67.3	+ 1.1	102	17	84	39	26	50	47	56	48	60	0.29	0.0	4	2,533	nw.	18	nw.	5	22	7	2	2.8	
Mid. Pac. Coast Reg.							65.8	− 1.0										60	0.02	0.0										3.7	
Eureka	62	62	80	29.97	30.04	+ .04	53.7	− 2.1	66	27	58	45	27	49	21	51	50	91	0.16	+ 0.1	5	4,338	nw.	33	n.	29	4	11	16	6.5	
Mount Tamalpais	2,375	11	18	27.51	29.94	+ .01	70.2	......	96	1	78	43	22	63	31	53	35	34	0.00	0.0	0	12,058	nw.	66	nw.	27	29	2	0	0.5	
Point Reyes Light	490	7	18	29.41	29.93	......	53.0	......	71	31	56	48	11	50	20	...	...	...	0.00	......	0	16,305	nw.	76	nw.	28	8	2	21	7.3	
Red Bluff	332	50	56	29.50	29.84	− .02	81.1	+ 0.1	114	7	96	55	23	66	38	61	46	36	0.00	0.0	0	3,613	se.	22	n.	29	28	3	0	0.5	
Sacramento	69	106	117	29.80	29.87	+ .02	71.4	− 0.7	103	7	87	50	24	56	41	59	51	55	0.00	0.0	0	6,923	s.	38	sw.	9	31	0	0	0.3	
San Francisco	155	200	204	29.78	29.95	+ .03	57.4	− 0.6	80	30	63	50	11	52	24	53	50	85	0.01	0.0	1	8,261	w.	38	sw.	9	11	10	10	5.0	
San Jose	141	78	88	29.80	29.94	......	65.2	− 1.5	92	1	78	43	25	52	45	...	...	...	0.00	0.0	0	4,193	nw.	36	sw.	9	29	2	0	1.9	
Southeast Farallon	30	9	17	29.94	29.97	......	53.3	......	63	31	56	48	16	51	12	...	...	...	0.00	0.0	0	11,105	nw.	50	n.	29	6	3	22	7.6	
S. Pac. Coast Reg.							70.9	+ 0.4										66	0.18	+ 0.2										2.1	
Fresno	330	67	70	29.50	29.85	+ .03	81.5	+ 0.3	113	8	100	52	30	64	42	60	42	34	0.00	0.0	0	4,115	nw.	20	w.	13	29	2	0	0.5	
Los Angeles	338	159	191	29.55	29.91	+ .03	70.2	+ 1.6	91	1	80	55	28	61	25	62	59	76	0.08	+ 0.1	1	4,039	sw.	20	sw.	19	24	6	1	2.7	
San Diego	87	94	102	29.82	29.91	+ .02	68.0	− 0.7	79	10	72	60	28	64	12	64	61	80	0.64	+ 0.6	1	4,456	w.	19	w.	19	25	4	2	2.6	
San Luis Obispo	201	47	54	29.74	29.96	+ .02	64.0	+ 0.5	96	1	76	45	25	52	42	56	53	75	0.00	0.0	0	3,242	nw.	17	nw.	28	25	6	0	2.5	
West Indies.																															
Grand Turk	11	6	20	......	......	......	......	......	...	...	...	...	...	...	...	...	...	...	......	......	...	......	......	...	......	...	...	...	...	...	
San Juan	82	48	90	29.91	30.00	+ .03	81.7	......	91	20	87	72	14	76	14	76	74	78	4.89	− 0.1	17	7,648	e.	32	se.	8	19	6	6	3.6	
Panama.																															
Christobal	74	...	...	29.85	29.87	......	78.8	......	87	4	83	72	15	74	15	76	75	90	16.89	......	26	5,182	s.	30	s.	7	4	17	10	6.4	
Bas Obispo	40	...	...	29.69	29.87	......	78.6	......	89	7	85	68	4	72	19	74	74	94	10.23	......	26	2,865	nw.	20	se.	3	0	11	20	7.6	
Ancon	...	...	...	29.77	29.85	......	80.2	......	93	20	88	69	4	73	20	75	74	88	11.48	......	21	4,728	nw.	27	se.	3	2	14	15	6.9	
Alhajuela	...	...	...	......	......	......	78.7	......	89	7	86	68	25	72	19	...	...	...	16.64	......	27	972	ne.	12	sw.	2	...	...	...	...	
Bohio	...	...	...	......	......	......	78.9	......	91	17	86	69	4	72	21	...	...	...	20.50	......	28	1,350	e.	19	s.	7	...	...	...	...	
Gatun	...	...	...	......	......	......	78.5	......	89	4	85	69	4	72	19	...	...	...	16.22	......	27	2,638	s.	18	n.	22	...	...	...	...	

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for storms in which the rate of fall equaled or exceeded 0.25 in any 5 minutes, or 0.80 inch in 1 hour, during August, 1908, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Asheville, N. C	23	2:10 p. m.	D. N. p. m.	2.09	2:33 p. m.	3:18 p. m.	0.01	0.23	0.42	0.77	0.89	1.10	1.29	1.42	1.53	1.61					
Atlanta, Ga	23	6:35 p. m.	10:55 p. m.	2.36	8:40 p. m.	9:25 p. m.	0.21	0.13	0.37	0.63	0.80	1.06	1.38	1.57	1.78	1.91					
Baltimore, Md	5	2:10 p. m.	4:35 p. m.	1.27	2:25 p. m.	2:48 p. m.	0.01	0.31	0.72	0.94	1.08	1.13									
Bismarck, N. Dak	10	5:48 p. m.	6:40 p. m.	1.03	5:49 p. m.	6:20 p. m.	T.	0.27	0.49	0.60	0.70	0.84	0.96								
Block Island, R. I	22	12:30 p. m.	5:51 p. m.	2.01	2:45 p. m.	3:52 p. m.	0.41	0.11	0.20	0.29	0.40	0.47	0.57	0.69	0.86	0.94	1.00	1.24	1.44		
Boston, Mass.	7	1:38 p. m.	4:45 p. m.	1.73	1:48 p. m.	2:33 p. m.	T.	0.07	0.11	0.23	0.57	1.13	1.30	1.52	1.54	1.62					
Cairo, Ill	7	2:50 p. m.	5:00 p. m.	1.33	3:01 p. m.	3:29 p. m.	0.01	0.22	0.41	3.74	0.91	1.00	1.04								
Charlotte, N. C	16	3:50 p. m.	5:35 p. m.	1.23	4:16 p. m.	5:06 p. m.	0.16	0.31	0.45	0.51	0.56	0.62	0.66	0.76	0.82	0.92	1.03				
Do	23	3:25 p. m.	9:15 p. m.	2.48	4:38 p. m.	5:03 p. m.	0.19	0.23	0.44	0.63	0.80	0.91									
					5:43 p. m.	6:21 p. m.	1.29	0.13	0.29	0.51	0.61	0.65	0.68	0.74	0.81						
Chattanooga, Tenn	4	3:41 p. m.	10:54 p. m.	1.62	5:34 p. m.	6:09 p. m.	0.17	0.17	0.17	0.18	0.31	0.56	0.72	0.81							
Do	5	9:10 a. m.	4:43 p. m.	1.44	11:03 a. m.	11:18 a. m.	0.20	0.10	0.25	0.47											
					2:35 p. m.	2:55 p. m.	0.83	0.11	0.22	0.37	0.51										
Do	5–6	5:20 p. m.	1:45 a. m.	1.86	7:17 p. m.	8:02 p. m.	0.21	0.07	0.18	1.23	0.25	0.35	0.47	0.61	0.75	0.83					
Chicago, Ill	11–12	8:40 p. m.	3:55 a. m.	3.30	9:39 p. m.	11:05 p. m.	0.05	0.30	0.57	0.74	0.94	1.03	1.04	1.05	1.06	1.06	1.08	1.39	1.70	1.98	
					11:51 p. m.	12:13 a. m.	2.06	0.07	0.27	0.48	0.53	0.58									
Columbia, Mo	6	5:31 a. m.	7:45 a. m.	1.24	6:36 a. m.	7:16 a. m.	0.01	0.14	0.25	0.30	0.44	0.62	0.85	1.11	1.22						
Do	28	5:36 p. m.	8:45 p. m.	2.03	5:46 p. m.	7:31 p. m.	0.04	0.13	0.20	0.24	0.26	0.39	0.75	1.04	1.11	1.27	1.34	1.41	1.58	1.82	1.98
Columbia, S. C	19	5:00 p. m.	11:45 p. m.	2.46	6:18 p. m.	6:46 p. m.	0.03	0.27	0.52	0.64	0.92	1.14	1.27								
					7:35 p. m.	7:54 p. m.	1.37	0.14	0.29	0.43	0.53										
Concord, N. H	5	6:12 p. m.	10:24 p. m.	1.76	7:44 p. m.	8:39 p. m.	0.21	0.07	0.12	0.15	0.30	0.50	0.83	0.95	0.99	1.00	1.06	1.35			
Concordia, Kans	6–7	10:55 p. m.	8:50 a. m.	2.91	2:26 a. m.	3:25 a. m.	1.40	0.14	0.31	0.37	0.48	0.52	0.57	0.60	0.64	0.72	0.78	0.95			
Do	26	3:32 p. m.	5:30 p. m.	2.54	3:38 p. m.	4:24 p. m.	0.01	0.10	0.41	0.83	1.36	1.78	2.09	2.23	2.35	2.43					
Davenport, Iowa	11–12	4:30 p. m.	11:20 a. m.	3.52	5:54 p. m.	6:24 p. m.	0.05	0.08	2.27	0.58	0.83	1.20	1.33								
					11:08 p. m.	11:38 p. m.	2.27	0.16	0.30	0.41	0.52	0.58	0.66								
Del Rio, Tex	20	3:50 p. m.	10:20 p. m.	1.37	4:34 p. m.	5:04 p. m.	0.25	0.20	0.39	0.53	0.63	0.82	0.88								
Des Moines, Iowa	14–15	7:45 p. m.	6:35 a. m.	4.31	8:51 p. m.	10:15 p. m.	0.26	0.23	0.30	0.34	0.43	0.54	0.84	0.92	1.02	1.19	1.40	2.10	3.05	3.16	
Evansville, Ind	10	4:10 p. m.	11:00 p. m.	3.76	5:33 p. m.	6:28 p. m.	0.58	0.12	0.30	0.50	0.71	1.05	1.53	1.86	2.01	2.25	2.45	2.50			
Flagstaff, Ariz	2	12:20 p. m.	4:50 p. m.	1.44	3:01 p. m.	3:30 p. m.	0.14	0.11	0.41	0.75	0.96	1.06	1.15								
Fort Smith, Ark	13	7:24 a. m.	12:44 p. m.	1.88	7:34 a. m.	9:28 a. m.	0.01	0.21	0.34	0.40	0.50	0.57	0.62	0.66	0.70	0.80	0.83	0.88	1.08	1.42	1.57
Do	19–20	9:00 p. m.	D. N. a. m.	2.98	11:02 p. m.	12:40 a. m.	0.03	0.23	0.60	0.92	1.24	1.52	1.73	1.79	1.92	2.01	2.03	2.06	2.31	2.70	
Fort Worth, Tex	23	2:40 a. m.	6:50 a. m.	1.33	4:06 a. m.	4:38 a. m.	0.26	0.12	0.32	0.48	0.62	0.70	0.77	0.80							
Galveston, Tex	17–18	9:00 p. m.	11:00 a. m.	2.09	12:16 a. m.	12:41 a. m.	0.80	0.18	0.29	0.47	0.66	0.75									
Grand Haven, Mich	3–4	8:04 p. m.	D. N. a. m.	3.23	8:43 p. m.	9:16 p. m.	0.09	0.07	0.31	0.47	0.61	0.74	0.86	0.94							
					3:07 a. m.	3:16 a. m.	2.88	0.14	0.35												
Do	15–16	8:25 p. m.	7:20 a. m.	1.82	4:33 a. m.	5:32 a. m.	0.53*	0.17*	0.26*	0.39*	0.46*	0.62*	0.68*	0.76*	0.89*	1.01*	1.08*	1.27*			
Grand Rapids, Mich	15–16	4:28 p. m.	7:50 a. m.	2.63	9:47 p. m.	10:34 p. m.	0.13	0.05	0.18	0.25	0.36	0.50	0.55	0.56	0.58	0.71	0.77				
					12:09 a. m.	12:38 a. m.	1.02	0.08	0.17	0.21	0.33	0.51	0.60								
					5:49 a. m.	6:12 a. m.	1.78	0.10	0.33	0.45	0.56	0.63									
Harrisburg, Pa	7	12 noon.	2:45 p. m.	1.17	12:22 p. m.	12:52 p. m.	0.03	0.35	0.71	0.89	0.93	0.96	1.08								
Hatteras, N. C	26	10:15 a. m.	1:45 p. m.	3.08	10:17 a. m.	12:07 p. m.	T.	0.10	0.30	0.48	0.70	1.03	1.36	1.41	1.57	1.66	1.68	1.95	2.61	2.88	3.06
Iola, Kans	31	5:25 p. m.	6:48 p. m.	1.03	5:29 p. m.	5:44 p. m.	0.01	0.47	0.80	0.99											
Jupiter, Fla	29	11:10 a. m.	1:35 p. m.	2.05	11:21 a. m.	11:56 a. m.	0.03	0.22	0.46	0.58	0.87	1.16	1.39	1.48							
Key West, Fla	5	4:10 a. m.	5:00 a. m.	1.00	4:15 a. m.	4:45 a. m.	T.	0.07	0.27	0.53	0.78	0.86	0.93								
Do	26–27	9:10 p. m.	D. N. a. m.	1.44	9:13 p. m.	9:38 p. m.	T.	0.35	0.77	1.04	1.23	1.37									
La Salle, Ill	15	5:49 p. m.	6:42 p. m.	1.02	5:49 p. m.	6:19 p. m.	0.00	0.23	0.66	0.75	0.78	0.92	1.00								
Macon, Ga	24–25	6:35 p. m.	5:25 p. m.	2.84	1:05 p. m.	2:00 p. m.	0.77	0.21	0.44	0.52	0.63	0.84	0.96	1.17	1.46	1.67	1.86	1.95			
Memphis, Tenn	4	12:45 p. m.	1:35 p. m.	0.50	1:19 p. m.	1:28 p. m.	0.01	0.24	0.49												
Do	4	4:14 p. m.	8:45 p. m.	1.24	6:24 p. m.	7:04 p. m.	0.07	0.13	0.26	0.34	0.41	0.51	0.60	0.68	0.77						
Meridian, Miss	2	D. N. a. m.	3:00 p. m.	1.85	10:25 a. m.	11:25 a. m.	0.50	0.05	0.15	0.20	0.23	0.28	0.40	0.48	0.56	0.80	0.86	1.00			
Montgomery, Ala	7	3:20 p. m.	4:35 p. m.	1.26	3:28 p. m.	4:07 p. m.	0.01	0.30	0.59	0.85	0.98	1.02	1.12	1.18	1.24						
Moorhead, Minn	29	8:04 a. m.	9:40 a. m.	2.00	8:04 a. m.	9:11 a. m.	0.00	0.34	1.02	1.24	1.28	1.33	1.34	1.35	1.38	1.40	1.40	1.72	1.98		
New Haven, Conn	22	5:25 a. m.	4:05 p. m.	2.93	11:02 a. m.	11:42 a. m.	0.82	0.08	0.27	0.50	0.67	0.87	1.00	1.19	1.24						
New Orleans, La	6	10:45 a. m.	12:05 p. m.	1.43	11:02 a. m.	11:49 a. m.	0.10	0.34	0.66	0.92	1.02	1.06	1.09	1.15	1.21	1.29					

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, etc.*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Norfolk, Va	23	10:15 a. m.	12:40 p. m.	1.87	10:23 a. m.	12: noon.	0.03	0.22	0.27	0.28	0.30	0.44	0.68	0.86	1.06	1.10	1.17	1.46	1.57	1.81	
Do	23-24	9:55 p. m.	D. N. a. m.	1.45	12:42 a. m.	1:15 a. m.	0.14	0.08	0.17	0.28	0.39	0.48	0.66	0.72							
Pensacola, Fla	24	2:05 p. m.	4:25 p. m.	1.25	2:15 p. m.	3:22 p. m.	0.01	0.05	0.15	0.26	0.43	0.63	0.72	0.72	0.72	0.73	0.75	0.93	1.18		
Port Huron, Mich	12	D. N. a. m.	8:15 a. m.	1.69	5:18 a. m.	5:43 a. m.	0.13	0.13	0.33	0.41	0.64	0.69									
					6:12 p. m.	6:37 a. m.	0.91	0.11	0.21	0.34	0.45	0.62									
Raleigh, N. C	23-24	9:00 p. m.	10:50 a. m.	2.42	5:46 p. m.	6:47 a. m.	0.26	0.15	0.38	0.59	0.66	0.70	0.89	1.00	1.12	1.20	1.25	1.35	1.47		
Do	24-25	1:30 p. m.	7:50 a. m.	3.74	2:56 p. m.	3:27 p. m.	0.10	0.06	0.23	0.37	0.41	0.50	0.76	0.79							
					4:57 p. m.	5:54 p. m.	0.98	0.08	0.19	0.23	0.37	0.45	0.49	0.49	0.50	0.61	0.71	0.88			
					11:20 p. m.	11:30 p. m.	2.63	0.18	0.36												
Do	25-26	9:35 p. m.	7:45 a. m.	1.70	9:41 p. m.	10:20 p. m.	0.01	0.11	0.15	0.27	0.36	0.48	0.51	0.61	0.65						
Richmond, Va	19	9:10 p. m.	10:25 p. m.	2.97	9:14 p. m.	10:00 p. m.	0.01	0.40	0.86	1.14	1.57	2.27	2.60	2.69	2.75	2.85	2.91				
San Antonio, Tex	19	1:00 p. m.	3:28 p. m.	1.18	1:03 p. m.	1:57 p. m.	0.01	0.11	0.22	0.29	0.33	0.37	0.50	0.66	0.86	0.99	1.07	1.14			
Do	20	2:05 p. m.	4:00 p. m.	1.19	2:37 p. m.	3:02 p. m.	0.04	0.12	0.31	0.73	0.98	1.11									
Sandusky, Ohio	5	D. N. a. m.	D. N. a. m.	1.00	1:57 a. m.	2:35 a. m.	0.01	0.19	0.24	0.35	0.46	0.67	0.80	0.90	0.92						
Sault Sainte Marie, Mich	3	3:40 a. m.	6:25 a. m.	1.18	5:40 a. m.	6:04 a. m.	0.42	0.15	0.36	0.51	0.63	0.74									
Savannah, Ga	24-25	D. N. p. m.	D. N. a. m.	0.82	11:55 p. m.	12:20 a. m.	0.02	0.29	0.58	0.64	0.73	0.79									
Sioux City, Iowa	15	5:50 p. m.	7:30 p. m.	1.19	6:30 p. m.	6:47 p. m.	0.02	0.18	0.60	0.86	0.93										
Springfield, Ill	29	5:43 a. m.	8:40 a. m.	1.36	6:19 a. m.	7:10 a. m.	0.10	0.25	0.31	0.33	0.40	0.46	0.57	0.73	0.77	0.85	1.03				
Tampa, Fla	27	3:20 p. m.	5:00 p. m.	1.77	3:56 p. m.	4:30 p. m.	0.23	0.05	0.38	0.62	0.81	1.17	1.44	1.54							
Do	30	3:03 p. m.	5:30 p. m.	1.89	3:10 p. m.	3:58 p. m.	T.	0.11	0.18	0.26	0.56	1.01	1.39	1.60	1.72	1.80	1.84				
Taylor, Tex	19	11:30 a. m.	12:05 p. m.	1.05	11:32 a. m.	12 noon.	T.	0.22	0.43	0.62	0.85	1.00	1.05								
Toledo, Ohio	5	12:02 a. m.	1:45 a. m.	1.80	12:47 a. m.	1:30 a. m.	0.17	0.28	0.35	0.43	0.49	0.71	1.09	1.35	1.49	1.61					
Topeka, Kans	6	4:18 p. m.	10:35 p. m.	1.30	7:50 p. m.	8:07 p. m.	0.48	0.19	0.42	0.56	0.61										
Do	7	12:15 a. m.	10:05 a. m.	2.63	5:52 a. m.	6:32 a. m.	1.48	0.06	0.10	0.21	0.30	0.39	0.51	0.55	0.64						
Do	19	3:59 a. m.	8:25 a. m.	1.10	4:36 a. m.	4:59 a. m.	0.08	0.24	0.42	0.58	0.71	0.77									
Do	26	5:35 p. m.	8:45 p. m.	1.00	6:20 p. m.	6:37 p. m.	0.04	0.08	0.30	0.50	0.54										
Wichita, Kans	26-27	10:25 p. m.	D. N. a. m.	3.57	11:57 p. m.	12:24 a. m.	0.07	0.06	0.11	0.28	0.70	1.00	1.02								
					1:53 a. m.	2:45 a. m.	1.15	0.17	0.41	0.57	0.83	0.98	1.22	1.54	1.87	2.17	2.36	2.40			
Wilmington, N. C	7	4:00 p. m.	4:50 p. m.	0.96	4:13 p. m.	4:41 p. m.	0.03	0.12	0.28	0.57	0.81	0.88	0.93								
Do	9	3:35 p. m.	6:55 p. m.	2.37	3:52 p. m.	3:58 p. m.	0.01	0.22	0.36												
					4:29 p. m.	5:46 p. m.	0.38	0.07	0.13	0.16	0.24	0.41	0.47	0.58	0.69	0.72	0.80	1.38	1.92		
Yankton, S. Dak	14	D. N. a. m.	8:55 a. m.	0.93	6:43 a. m.	7:40 a. m.	0.08	0.11	0.22	0.32	0.34	0.34	0.35	0.38	0.46	0.62	0.71	0.84			

*Partly estimated.

TABLE III.—*Data furnished by the Canadian Meteorological Service, August, 1908.*

Stations.	Pressure. Actual, reduced to mean of 24 hours.	Pressure. Sea level, reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature. Mean.	Temperature. Departure from normal.	Temperature. Mean maximum.	Temperature. Mean minimum.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Total snowfall.
	Ins.	*Ins.*	*Ins.*	°	°	°	°	*Ins.*	*Ins.*	*Ins.*
St. Johns, N. F	29.86	29.99	+.03	60.3	+ 0.5	67.4	53.2	2.01	−2.07	.....
Sydney, C. B. I	29.98	30.02	+.07	62.9	− 0.4	72.1	53.7	2.26	−1.36	.....
Halifax, N. S	29.92	30.02	+.06	62.6	− 1.0	71.6	53.6	10.66	+6.31	.....
Grand Manan, N. B	29.94	29.99	+.04	61.8	+ 0.3	69.3	54.3	4.98	+1.32	.....
Yarmouth, N. S	29.96	30.03	+.06	59.6	− 0.6	66.9	52.2	4.21	+0.20	.....
Charlottetown, P. E. I	29.94	29.98	+.04	64.2	− 0.1	71.6	56.9	5.53	+1.79	.....
Chatham, N. B	29.94	29.96	+.03	64.9	+ 1.7	75.9	53.9	4.15	+0.11	.....
Father Point, Que	29.91	29.93	+.02	56.0	+ 0.4	64.2	47.9	3.86	+0.81	.....
Quebec, Que	29.65	29.97	+.04	63.5	+ 0.4	72.5	54.4	5.72	+1.89	.....
Montreal, Que	29.76	29.96	+.01	66.6	+ 0.2	74.2	59.1	2.83	−0.74	.....
Rockliffe, Ont	29.37	29.97	+.01	60.1	− 3.1	71.0	49.2	1.42	−1.53	.....
Ottawa, Ont	29.73	.....	.....	66.7	+ 1.9	77.9	55.5	1.43	−1.60	.....
Kingston, Ont	29.70	30.01	+.03	65.5	− 1.5	73.6	57.4	2.77	+0.39	.....
Toronto, Ont	29.66	30.02	+.03	67.0	+ 1.0	77.8	56.1	2.83	+0.07	.....
White River, Ont	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Port Stanley, Ont	29.39	30.02	+.02	65.9	.0.0	75.9	55.9	4.83	+1.91	.....
Southampton, Ont	29.32	.....	.....	65.2	+ 1.4	73.7	56.7	2.14	−0.11	.....
Parry Sound, Ont	29.33	30.01	+.03	65.7	+ 2.2	76.8	54.5	3.74	+1.02	....
Port Arthur, Ont	29.26	29.97	+.01	60.6	+ 1.1	71.8	49.4	3.71	+0.96	....
Winnipeg, Man	29.12	29.94	.00	62.2	− 1.2	74.3	50.0	2.44	−0.23	....
Minnedosa, Man	28.13	29.92	−.02	58.4	− 1.0	70.9	46.0	2.83	+0.73	....
Qu' Appelle, Assin	27.70	29.93	.00	58.0	− 3.5	69.4	46.6	1.91	+0.27	....
Medicine Hat, Alberta	27.70	29.94	+.02	64.8	− 0.9	78.5	51.2	1.34	−0.33	....
Swift Current, Sask	27.43	29.96	+.03	61.5	− 2.5	74.8	48.1	1.12	−0.79	....
Calgary, Alberta	26.46	29.94	+.03	57.8	− 1.6	71.3	44.4	1.52	−0.62	....
Banff, Alberta	25.44	29.97	+.06	55.7	− 0.6	70.4	40.9	1.74	−0.79	....
Edmonton, Alberta	27.67	29.93	+.01	58.5	− 0.3	70.6	46.4	1.71	−0.42	....
Prince Albert, Sask	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Battleford, Sask	28.21	29.94	+.03	57.4	− 5.2	70.2	44.7	1.58	−0.78	....
Kamloops, B. C	28.65	29.84	−.07	68.8	+ 0.2	65.9	41.4	1.46	+0.37	....
Victoria, B. C	29.93	30.02	+.01	61.0	+ 2.3	70.5	51.4	0.67	+0.07	....
Barkerville, B. C	25.75	30.03	+.13	53.7	− 2.6	81.4	56.2	3.72	+0.62	....
Hamilton, Bermuda	29.97	30.13	+.03	80.8	+ 1.2	86.5	75.2	1.82	−4.26	....
Dawson, Yukon	.....	.....	.....	.....	.....	.....	.....	.....	.....	....

TABLE IV.—*Heights of rivers referred to zeros of gages, August, 1908.*

Stations.	Distance to mouth of river.	Flood stage on gage.	Highest water. Height.	Highest water. Date.	Lowest water. Height.	Lowest water. Date.	Mean stage.	Monthly range.
	Miles.	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Republican River.								
Clay Center, Kans	42	18	13.8	21	6.7	31	8.9	7.1
Smoky Hill-Kansas River.								
Abilene, Kans	254	22	8.2	29	2.6	8,19	4.4	5.6
Manhattan, Kans	160	18	11.5	22	4.3	18	6.5	7.2
Topeka, Kans	87	21	13.7	23	7.8	6,19	9.9	5.9
Missouri River.								
Townsend, Mont	2,504	11	4.9	1	4.3	12,13, 15-17	4.5	0.6
Fort Benton, Mont	2,285	12	3.5	1	1.0	23,24, 27-31	1.9	2.5
Wolfpoint, Mont	1,952	17	0.9	1	− 1.2	19-27	−0.7	2.1
Bismarck, N. Dak	1,309	14	6.0	1	3.3	21,22	4.2	2.7
Pierre, S. Dak	1,114	14	5.6	1	2.5	22,26-28	3.4	3.1
Sioux City, Iowa	784	17	9.6	3,4	6.3	29,31	7.8	3.3
Blair, Nebr	705	15	9.4	1	6.0	30,31	7.8	3.4
Omaha, Nebr	669	18	12.6	4,5	9.7	31	11.3	2.9
St. Joseph, Mo	481	10	7.4	1	3.6	31	5.4	3.8
Kansas City, Mo	388	21	14.0	1	11.1	16,17, 19,31	12.1	2.9
Glasgow, Mo	231	21	14.6	1	11.3	29	12.5	3.3
Boonville, Mo	199	20	14.5	1	11.6	18,19	12.5	2.9
Hermann, Mo	103	24	13.0	1	9.8	20,22	10.9	3.2
Minnesota River.								
Mankato, Minn	127	18	7.7	1	3.5	27	4.9	4.2
St. Croix River.								
Stillwater, Minn	23	11	7.5	1,2	3.0	28	4.9	4.5
Illinois River.								
La Salle, Ill	197	18	13.3	14	11.8	30,31	12.4	1.5
Peoria, Ill	135	14	9.5	20,21	8.5	31	9.0	1.0
Conemaugh River.								
Johnstown, Pa	64	7	1.0	6-8,18, 22,23	0.5	17,30,31	0.8	0.5
Allegheny River.								
Warren, Pa	177	14	1.0	19,20	− 0.3	31	0.5	1.3
Parker, Pa	73	20	1.3	6-8	0.2	30,31	0.8	1.1
Freeport, Pa	29	20	2.8	9,10	0.7	30,31	1.7	2.1
Springdale, Pa	17	—	7.2	1,9	5.6	31	6.5	1.6
Youghiogheny River.								
Confluence, Pa	59	10	0.4	7,24	0.1	12-17, 27-31	0.2	0.3
West Newton, Pa	15	23	1.0	7,20	0.1	17,18	0.5	0.9
Monongahela River.								
Fairmont, W. Va	119	25	14.8	7	13.9	29-31	14.2	0.9
Greensboro, Pa	81	18	7.2	1	6.3	27,28	6.7	0.9
Lock No. 4, Pa	40	28	8.9	31	6.9	20,21, 23,24	7.4	2.0
Muskingum River.								
Zanesville, Ohio	70	25	8.9	7,8	7.8	23-31	8.1	1.1
Little Kanawha River.								
Creston, W. Va	38	20	2.3	1,6,7	0.7	31	1.7	1.6
New-Great Kanawha River.								
Hinton, W. Va	153	14	5.0	27	1.4	23,24	2.4	3.6
Charleston, W. Va	58	30	8.8	28	4.6	1	6.9	4.2
Scioto River.								
Columbus, Ohio	110	17	3.2	6	1.8	3,4,31	2.5	1.4
Licking River.								
Falmouth, Ky	30	25	2.0	9	0.5	29-31	0.8	1.5
Kentucky River.								
Beattyville, Ky	254	30	2.3	9,11	0.0	25-31	0.6	2.3
Frankfort, Ky	65	31	6.8	11,12	5.0	29-31	5.7	1.8
Wabash River.								
Mount Carmel, Ill	75	15	3.2	18	0.9	31	2.0	2.3
Cumberland River.								
Burnside, Ky	518	50	2.2	10	− 0.1	21,22	0.6	2.3
Celina, Tenn	383	45	3.3	13	1.3	21,22	1.9	2.0
Carthage, Tenn	308	40	2.3	14,15	1.2	31	1.7	1.1
Nashville, Tenn	193	40	8.3	1	7.4	8,9	7.7	0.9
Clarksville, Tenn	126	43	4.2	20	2.0	30,31	3.2	2.2
Clinch River.								
Speers Ferry, Va	156	20	1.4	10	0.0	31	0.5	1.4
Clinton, Tenn	52	25	7.0	25	3.0	6	4.2	4.0
South Fork Holston River.								
Bluff City, Tenn	35	12	1.4	10	0.5	3,5,8, 14-18,21	0.7	0.9
Holston River.								
Rogersville, Tenn	103	14	3.4	27	1.7	19	2.2	1.7
French Broad River.								
Asheville, N. C	144	4	4.9	26	− 0.2	2,3	0.8	5.1
Dandridge, Tenn	46	12	5.8	27	0.9	17	1.9	4.9
Tennessee River.								
Knoxville, Tenn	635	12	7.4	27	0.6	17	2.4	6.8
Loudon, Tenn	590	25	5.2	28	1.2	17-19	2.4	4.0
Kingston, Tenn	556	25	5.3	28	1.8	19-20	2.9	3.5
Chattanooga, Tenn	452	33	7.7	25	2.8	5	4.4	4.9
Bridgeport, Ala	402	24	5.0	25	0.9	20	2.6	4.1
Guntersville, Ala	349	31	8.1	26	2.9	21,22	4.7	5.2
Florence, Ala	255	16	4.2	27	0.7	2	1.9	3.5
Riverton, Ala	225	26	7.4	27	2.6	3,21	4.1	4.8
Johnsonville, Tenn	95	21	6.0	29	2.5	5	3.7	3.5
Ohio River.								
Pittsburg, Pa	966	22	6.0	9	4.8	13	5.4	1.2
Coraopolis, Pa	956	25	9.9	10,22	6.7	2	9.1	3.2
Beaver Dam, Pa	937	27	5.0	1	1.7	31	3.3	3.3
Wheeling, W. Va	875	36	4.4	7	1.4	30	2.8	3.0
Parkersburg, W. Va	785	36	7.2	1	1.6	31	3.6	5.6
Point Pleasant, W. Va	703	39	7.7	1	1.9	25	3.5	5.8
Huntington, W. Va	660	50	11.8	1	4.4	26	6.7	7.4
Catlettsburg, Ky	651	50	11.5	1	3.2	26	5.2	8.3
Portsmouth, Ohio	612	50	12.4	1	3.6	27	6.4	8.8
Maysville, Ky	559	50	13.2	1	4.2	28	7.0	9.0
Cincinnati, Ohio	499	50	15.3	1	5.4	29	8.6	9.9
Madison, Ind	413	46	12.5	2	4.6	25	7.6	7.9
Louisville, Ky	367	28	6.8	2	2.7	23-31	4.2	4.1
Evansville, Ind	184	35	10.0	5	4.1	31	6.9	5.9
Mount Vernon, Ind	148	35	9.7	5	4.3	31	6.8	5.4
Paducah, Ky	47	40	8.4	1	4.2	27	6.3	4.2
Cairo, Ill	1	45	22.0	1	13.9	28	17.2	8.1
Neosho River.								
Iola, Kans	262	10	2.0	23	− 0.4	18	0.3	2.4
Oswego, Kans	184	20	2.8	24	0.4	17-23	0.9	2.4
Fort Gibson, Okla	3	22	10.5	3	9.0	31	9.8	1.5
Canadian River.								
Calvin, Okla	99	10	4.4	28	2.7	8,9	3.3	1.7
Black River.								
Blackrock, Ark	67	12	5.7	9	3.0	31	3.9	2.7
White River.								
Calicorock, Ark	272	18	2.6	15	0.3	7	1.3	2.3
Batesville, Ark	217	18	4.2	16	2.4	4-7	3.1	1.8
Clarendon, Ark	75	30	12.0	25,26	10.5	11	11.2	1.5
Arkansas River.								
Wichita, Kans	832	10	− 0.8	24	− 2.1	18	−1.6	1.3
Tulsa, Okla	551	16	4.1	31	2.4	13-19,24	3.0	1.7
Webbers Falls, Okla	465	23	7.0	27,28	5.4	15-19	6.1	1.6
Fort Smith, Ark	403	22	7.4	20	5.2	27	5.8	2.2
Dardanelle, Ark	256	21	6.6	3	5.1	13,19,20	5.8	1.5
Little Rock, Ark	176	23	6.5	1,5,16	4.9	14	5.7	1.6
Pine Bluff, Ark	121	25	10.2	1	8.4	15	9.2	1.8
Yazoo River.								
Greenwood, Miss	175	38	5.6	14	3.5	31	4.7	2.1
Yazoo City, Miss	80	25	5.4	5	1.8	31	3.3	3.6
Ouachita River.								
Camden, Ark	304	39	6.8	11	4.0	20,31	5.1	2.8
Monroe, La	122	40	20.1	5	4.0	31	13.2	16.1
Red River								
Arthur City, Tex	688	27	10.8	2	6.6	21,24	7.8	4.2
Fulton, Ark	515	28	17.4	1	9.5	25,28,29	12.1	7.9

TABLE IV.—*Heights of rivers referred to zeros of gages*—Continued.

Stations.	Distance to mouth of river.	Flood stage on gage.	Highest water. Height.	Highest water. Date.	Lowest water. Height.	Lowest water. Date.	Mean stage.	Monthly range.
Red River—Cont'd.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Shreveport, La.	327	29	9.9	1	0.7	31	4.5	9.2
Alexandria, La.	118	36	23.8	1	7.5	31	14.5	16.3
Mississippi River.								
Fort Ripley, Minn	2,082	10	5.5	1-4	4.2	17	4.9	1.3
St. Paul, Minn.	1,954	14	7.3	1	3.8	31	5.0	3.5
Red Wing, Minn.	1,914	14	5.0	1,2	1.8	28-31	3.2	3.2
Reeds Landing, Minn.	1,884	12	5.0	1	1.6	29-31	3.1	3.4
La Crosse, Wis.	1,819	12	6.3	1	2.8	31	4.5	3.5
Prairie du Chien, Wis.	1,759	18	7.4	1	3.0	31	4.9	4.4
Dubuque, Iowa.	1,699	18	8.2	1	3.4	31	5.5	4.8
Clinton, Iowa	1,629	16	8.0	1	3.3	31	5.4	4.7
Leclaire, Iowa	1,609	10	4.5	1	1.6	28-31	2.8	2.9
Davenport, Iowa	1,593	15	7.0	1	3.1	31	4.9	3.9
Muscatine, Iowa	1,562	16	8.3	1	4.0	28,30,31	5.9	4.3
Galland, Iowa.	1,472	8	4.4	1	1.8	28,29	2.9	2.6
Keokuk, Iowa.	1,463	15	8.3	1	3.6	29,30	5.6	4.7
Warsaw, Ill	1,458	18	11.4	1	6.8	29	8.8	4.6
Hannibal, Mo	1,402	13	10.0	1	4.6	30	7.0	5.4
Grafton, Ill	1,306	23	12.7	1	6.8	31	9.1	5.5
St. Louis, Mo	1,264	30	19.3	1	10.3	31	13.6	9.0
Chester, Ill	1,189	30	17.0	1	10.0	31	12.1	7.0
New Madrid, Mo.	1,003	34	18.9	1	11.8	29	14.7	7.1
Memphis, Tenn	843	33	17.3	1	10.9	30,31	13.7	6.4
Helena, Ark.	767	42	22.0	1	13.0	31	17.2	9.0
Arkansas City, Ark.	635	42	25.4	1	15.2	31	20.0	10.2
Greenville, Miss.	595	42	20.9	1	12.3	31	16.2	8.6
Vicksburg, Miss.	474	45	25.0	1	13.5	31	18.8	11.5
Natchez, Miss.	373	46	30.1	2	16.1	31	22.4	14.0
Baton Rouge, La.	240	35	25.0	1	10.4	31	17.4	14.6
Donaldsonville, La	188	28	18.8	1	7.7	31	13.0	11.1
New Orleans, La.	108	18	12.5	1	5.7	30	8.9	6.8
Atchafalaya River.								
Simmesport, La.	127	41	31.0	1	14.1	31	22.7	16.9
Melville, La.	103	37	31.0	1	18.5	31	25.4	12.5
Morgan City, La.	19	8	5.2	2	3.7	26	4.3	1.5
Hudson River.								
Troy, N. Y.	154	14	4.2	1,14,15	2.7	4,29	3.4	1.5
Albany, N. Y.	147	12	4.6	29	1.3	7	3.1	3.3
Delaware River.								
Hancock (E. Branch), N. Y.	287	12	2.8	1	2.4	21,26, 30,31	2.6	0.4
Hancock (W. Branch), N. Y.	287	10	2.8	1	2.3	21,22, 27-31	2.5	0.5
Port Jervis, N. Y.	215	14	— 0.3	1-3	— 0.9	18	—0.6	0.6
Phillipsburg, N. J.	146	26	0.6	1	0.0	21,22,31	0.3	0.6
Trenton, N. J.	92	18	1.8	7	0.4	18-22	0.7	1.4
North Branch Susquehanna.								
Binghamton, N. Y.	183	14	1.9	1,2	1.6	16,23,30	1.7	0.3
Wilkes-Barre, Pa.	60	17	3.0	1	2.3	28-31	2.6	0.7
West Branch Susquehanna.								
Williamsport, Pa.	39	20	1.4	8	0.5	3,4,29-31	0.8	0.9
Susquehanna River.								
Harrisburg, Pa.	69	17	1.6	1	0.7	31	1.1	0.9
Shenandoah River.								
Riverton, Va.	58	22	4.7	27	— 0.8	4-8,12-17	—0.2	5.5
Potomac River.								
Cumberland, Md.	290	8	3.7	1	2.0	6-27	2.3	1.7
Harpers Ferry, W. Va.	172	18	3.0	27,28	— 0.2	13-17	0.8	3.2
James River.								
Lynchburg, Va.	260	20	5.0	26	0.7	17,18	1.3	4.3
Columbia, Va.	167	18	19.1	26	3.2	23-25	5.3	15.9
Richmond, Va.	111	10	11.7	27	0.0	23-25	1.5	11.7
Dan River.								
Danville, Va	55	8	9.5	26	— 0.1	18,19	0.9	9.6
Roanoke River.								
Clarksville, Va	196	12	13.6	26	— 0.1	20	2.2	13.7
Weldon, N. C.	129	30	45.4	28	10.1	19	16.7	35.3
Tar River.								
Greenville, N. C.	21	22	18.1	31	4.1	18	9.4	14.0
Deep River.								
Moncure, N. C.	171	25	34.3	26	7.1	6	11.8	27.2
Cape Fear River.								
Fayetteville, N. C	112	38	67.5	29	3.7	15	19.5	63.8
Pedee River.								
Cheraw, S. C.	149	27	44.3	27	2.0	18	11.1	42.3
Smiths Mills, S. C.	51	16	19.4	31	3.0	19	7.2	16.4
Lynch Creek.								
Effingham, S. C.	35	12	20.0	30	3.7	12	6.8	16.3
Black River.								
Kingstree, S. C.	45	12	6.9	30,31	0.4	17,18	2.2	6.5
Catawba-Wateree River.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Mount Holly, N. C.	143	15	14.2	26	1.8	2,4-7, 17-18	3.4	12.4
Catawba, S. C	107	11	28.4	25	2.5	19	7.0	25.9
Camden, S. C.	37	24	39.7	26	4.8	16	13.5	34.9
Congaree River.								
Columbia, S. C	52	15	35.8	27	0.4	16	6.5	35.4
Santee River.								
Ferguson, S. C.	82	12	23.7	31	6.5	6	11.1	17.2
Savannah River.								
Calhoun Falls, S. C.	347	15	23.8	25	2.2	5,6	4.5	21.6
Augusta, Ga.	268	32	38.8	27	6.9	18	12.5	31.9
Oconee River.								
Dublin, Ga	79	30	23.2	30	0.1	4,5	4.9	23.1
Ocmulgee River.								
Macon, Ga.	134	18	17.5	25	2.0	18	5.0	15.5
Abbeville, Ga.	51	11	9.7	31	1.7	20	3.8	8.0
Flint River.								
Montezuma, Ga.	152	20	12.0	30	1.9	21	4.8	10.1
Albany, Ga.	99	20	7.8	31	1.0	22	2.7	6.8
Bainbridge, Ga.	22	22	10.9	31	5.0	21	6.9	5.9
Chattahoochee River.								
West Point, Ga	174	20	8.9	26	1.9	17	8.3	7.0
Eufaula, Ala	90	40	17.0	27	1.3	17,18	4.5	15.7
Alaga, Ala.	30	25	16.9	28	3.1	18,19	6.1	13.8
Coosa River.								
Rome, Ga.	266	30	4.2	26	0.9	19	1.7	3.3
Gadsden, Ala.	162	22	4.1	25,26	0.9	18,19	2.2	3.2
Lock No. 4, Ala.	113	17	3.6	25	0.6	6,18-20	1.6	3.0
Wetumpka, Ala	12	45	6.8	27	2.1	18	4.0	4.7
Alabama River.								
Montgomery, Ala.	323	35	4.2	28	1.2	18-20	2.3	3.0
Selma, Ala	246	35	4.8	29	0.6	20	2.5	4.2
Black Warrior River.								
Tuscaloosa, Ala.	90	43	7.0	3	5.0	16,18,19	5.8	2.0
Tombigbee River.								
Columbus, Miss.	316	33	2.8	9	— 2.2	31	—0.2	5.0
Demopolis, Ala.	168	35	12.7	6	1.5	31	4.9	11.2
Pascagoula River.								
Merrill, Miss.	78	20	10.5	8	2.5	19	5.3	8.0
Pearl River.								
Columbia, Miss.	110	18	12.6	5	5.0	31	8.2	7.6
Sabine River.								
Logansport, La.	315	25	9.5	29	1.6	19	3.9	7.9
Neches River.								
Beaumont, Tex.	18	10	1.4	9,21,23,31	0.5	1	1.1	0.9
Trinity River.								
Dallas, Tex.	320	25	13.5	26	5.2	19,20	6.8	8.3
Long Lake, Tex.	211	35	27.0	31	6.0	23	14.3	21.0
Liberty, Tex	20	25	14.4	8	5.8	30	9.3	8.6
Brazos River.								
Waco, Tex.	285	22	7.8	28	2.4	16	3.3	5.4
Hempstead, Tex	140	40	6.4	6	1.4	31	3.7	5.0
Booth, Tex	61	39	6.4	1,2	4.5	31	5.3	1.9
Colorado River.								
Austin, Tex.	214	18	5.2	10	1.4	4	2.4	3.8
Columbus, Tex.	98	24	12.3	12	6.7	27,28	8.0	5.6
Red River of the North.								
Moorhead, Minn	284	26	10.0	1	8.4	26-28	9.1	1.6
Rio Grande.								
San Marcial, N. Mex.	1,233	11	12.5	p. m., 9	8.9	a. m., 9	10.3	3.6
El Paso, Tex.	1,030	14	12.4	19,27	10.0	3,4,12	11.1	2.4
Snake River.								
Lewiston, Idaho	144	24	2.0	1	0.7	14,15, 19,20	1.1	1.3
Riparia, Wash.	67	30	3.1	1	1.4	30,31	1.9	1.7
Columbia River.								
Wenatchee, Wash	473	40	28.0	1	14.0	31	20.3	14.0
Umatilla, Oreg	270	25	12.5	1	6.8	31	8.6	5.7
The Dalles, Oreg.	166	40	19.7	1	9.3	26-29	12.5	10.4
Willamette River.								
Albany, Oreg.	118	20	1.5	1-7	1.0	18-29	1.2	0.5
Portland, Oreg.	12	15	10.7	1	4.5	31	6.7	6.2
Sacramento River.								
Red Bluff, Cal.	265	23	0.8	1-8	0.5	29-31	0.7	0.3
Colusa, Cal.	156	28	2.6	1,2	2.0	31	2.3	0.6
Knights Landing, Cal.	99	18	1.3	1,2	0.5	28-31	0.8	0.8
Sacramento, Cal.	64	25	6.4	1,2	5.6	29	6.0	0.8
San Joaquin River.								
Pollasky, Cal.	203	10	1.3	7	0.0	14-31	0.2	1.3
Firebaugh, Cal	148	14	0.8	7	— 1.3	30,31	0.5	2.1
Lathrop, Cal.	49	14	1.0	1,2,24	0.0	30,31	0.7	1.0

Honolulu, T. H., latitude 21° 18′ north, longitude 157° 51′ west; barometer above sea, 38 feet; gravity correction, —0.057 inch, applied. August, 1908.

Day.	Pressure, in inches.*		Air temperature, degrees Fahrenheit.				Moisture.				Wind, in miles per hour.				Precipitation, inches.		Clouds.					
							8 a. m.		8 p. m.		8 a. m.		8 p. m.				8 a. m.			8 p. m.		
	8 a. m.	8 p. m.	8 a. m.	8 p. m.	Maximum.	Minimum.	Wet.	Relative humidity.	Wet.	Relative humidity.	Direction.	Velocity.	Direction.	Velocity.	8 a. m.	8 p. m.	Amount.	Kind.	Direction, from.	Amount.	Kind.	Direction, from.
							°	%	°	%												
1	30.07	30.04	77.0	75.0	82	73	66.8	58	67.0	66	e.	12	ne.	10	T.	0.00	2	Cu.	e.	1	Cu.	ne.
2	30.07	30.03	76.2	75.5	82	70	68.0	65	68.5	70	e.	6	e.	10	0.05	0.00	8	S.-cu.	ne.	1	Cu.	ne.
3	30.03	30.04	78.4	75.0	81	71	67.2	56	69.0	74	ne.	12	e.	12	0.00	0.02	Few Few	Cu. Cu.-n.	e. 0	3 1	A.-s. Cu.	w. ne.
4	30.05	30.04	78.0	75.5	82	71	69.0	63	58.6	68	ne.	12	e.	6	0.00	0.00	Few	Cu.	0	Few	Cu.	ne.
5	30.04	30.01	79.0	76.0	82	75	69.5	62	68.5	68	ne.	14	se.	10	0.00	0.00	Few	Cu.	0	4 4	Ci.-s. Cu.	s. ne.
6	30.01	29.98	78.0	75.5	82	74	69.2	64	69.0	72	ne.	7	e.	5	0.00	T.	6 2	Ci. Cu.	w. e.	1 8	A.-s. Cu.	sw. ne.
7	30.03	29.99	76.2	75.3	81	73	70.0	73	67.0	65	e.	4	ne.	15	0.00	T.	8	S.-cu.	e.	6 1	Ci.-s. Cu.	nw. sw.
8	30.07	30.04	79.0	75.5	82	73	63.0	60	70.0	76	e.	13	e.	5	0.00	T.	6 2	A.-cu. S.-cu.	nw. e.	2 7	Ci.-cu. Cu.	s. e.
9	30.04	29.99	77.5	76.0	82	72	70.0	69	69.0	70	e.	7	ne.	2	T.	0.00	6	S.-cu.	ne.	10	Cu.	ne.
10	30.00	30.00	77.6	74.5	82	72	68.0	61	67.0	68	e.	10	e.	4	0.00	0.00	4	Cu.	e.	Few Few	S.-cu. Cu.	ne. ne.
11	30.05	30.02	76.0	75.0	82	71	67.0	62	67.0	66	ne.	2	ne.	9	0.00	0.00	8	S.-cu.	e.	Few 1	S.-cu. Cu.	e. ne.
12	30.06	29.99	75.6	75.5	82	72	70.0	75	72.0	84	e.	2	e.	3	0.01	0.05	8	S.-cu.	ne.	10	N.	ne.
13	30.04	30.02	75.2	74.5	82	72	72.3	87	72.0	89	ne.	4	e.	2	0.48	0.03	9	S.-cu.	e.	10	N.	ne.
14	30.04	30.01	77.8	75.5	82	73	70.0	68	69.0	72	ne.	5	e.	7	T.	0.00	6 2	A.-cu. S.-cu.	e. e.	2	S.-cu.	ne.
15	30.03	30.02	78.2	75.5	82	72	70.2	67	69.0	72	e.	5	ne.	8	0.00	0.00	Few 4	Ci.-s. Cu.	0 e.	9	S.	e.
16	30.01	30.00	77.6	75.0	82	72	68.1	62	69.0	74	ne.	4	e.	4	0.00	0.00	4	Cu.	ne.	4 3	A.-s. Cu.	sw. ne.
17	30.02	30.01	79.0	75.5	84	72	69.0	60	69.0	72	e.	4	e.	10	0.00	0.00	Few	Cu.	0	0	0	0
18	30.06	30.03	78.4	75.0	83	71	71.2	70	68.0	70	ne.	2	ne.	8	0.00	0.00	3	Cu.	e.	0	0	0
19	30.04	30.00	78.0	75.5	83	72	68.0	60	68.0	68	e.	5	ne.	5	0.00	0.00	4	Cu.	ne.	0	0	0
20	30.02	30.00	73.0	75.5	81	70	68.0	78	67.5	66	n.	2	ne.	7	T.	0.01	7	N.	ne.	3	S.	e.
21	30.01	29.99	76.0	74.0	82	71	68.0	66	68.0	74	ne.	4	ne.	4	0.00	0.00	3	Cu.	e.	0	0	0
22	30.01	29.97	77.0	75.0	82	72	68.0	63	67.0	66	se.	2	ne.	2	0.00	0.00	7	Cu.	e.	0	0	0
23	29.99	29.99	76.2	76.0	83	73	68.0	65	68.0	66	e.	5	ne.	5	T.	0.00	5	Cu.	e.	2 1	A.-s. Cu.	0 ? e.
24	30.01	30.00	77.0	77.0	82	72	70.0	71	69.0	67	e.	12	e.	9	0.01	T.	5	Cu.	e.	2 7	A.-s. S.	sw. ne.
25	30.04	30.01	78.3	75.0	82	71	68.0	59	70.0	78	se.	8	e.	4	T.	0.02	1 6	Ci. S.-cu.	0 e.	9	N.	e.
26	30.04	30.05	79.3	77.0	82	73	70.2	64	68.0	63	e.	12	ne.	10	0.05	0.00	5	Cu.	e.	2	S.	e.
27	30.08	30.06	78.0	76.0	85	75	69.2	64	67.0	62	e.	9	e.	10	0.00	0.00	5	Cu.	e.	Few	Cu.	ne.
28	30.07	30.03	78.0	75.0	82	73	67.0	56	69.0	74	e.	5	ne.	14	0.00	0.00	2	Cu.	ne.	0	0	0
29	30.01	29.98	76.0	77.0	80	71	71.0	78	72.0	79	w.	4	e.	2	0.00	0.00	7	S.-cu.	e.	3	S.	ne.
30	30.00	29.98	79.0	76.0	83	74	71.0	68	72.0	82	e.	8	ne.	3	0.00	T.	9	S.-cu.	e.	4	A.-s.	sw.
31	30.01	29.99	78.2	75.5	83	72	71.9	70	73.0	89	ne.	12	ne.	8	0.02	0.04	4 5	S.-cu. N.	e. e.	10	N.	e.
Mean	30.034	30.010	77.4	75.5	82.1	72.2	69.1	65.9	68.9	71.9	e.	6.9	ne. e.	6.9	0.62	0.17	5.3	Cu.	e.	4.2	Cu.	ne.

Observations are made at 8 a.m. and 8 p. m., local standard time, which is that of 157° 30′ west, and is 5h and 30m slower than 75th meridian time. *Pressure values are reduced to sea level and standard gravity.

RAINFALL IN JAMAICA.

Thru the kindness of Mr. Maxwell Hall, meteorologist to the government of Jamaica and now in charge of the meteorological service of that island, we have received the following data:

Comparative table of rainfall.

[Based upon the average stations only.]

AUGUST, 1908.

Divisions.	Relative area.	Number of stations.	Rainfall.	
			1908.	Average.
	Per cent.		*Inches.*	*Inches.*
Northeastern division	25	21	6.63	7.62
Northern division	22	49	5.40	4.35
West-central division	26	19	10.65	9.27
Southern division	27	30	5.34	5.20
Means	100	....	7.00	6.63

The rainfall over the island for August, 1908, was the average; the forecast was therefore verified. The greatest rainfall recorded was 21.31 inches, at Troy, in the west-central division; the lowest rainfall recorded was 0.57 inch, at Buff Bay, in the southern division.

At Georgetown, Grand Cayman, the total rainfall for August, 1908, was 1.96 inches, on 9 days; the greatest daily fall was 0.54 inch, on August 29.

Correction.—The mean rainfall for the island for July, 1908, as given in the MONTHLY WEATHER REVIEW for July, 1908, should be 5.52 inches, not 0.52 inch, as there printed.

Chart I. Hydrographs for Seven Principal Rivers of the United States, August, 1908.

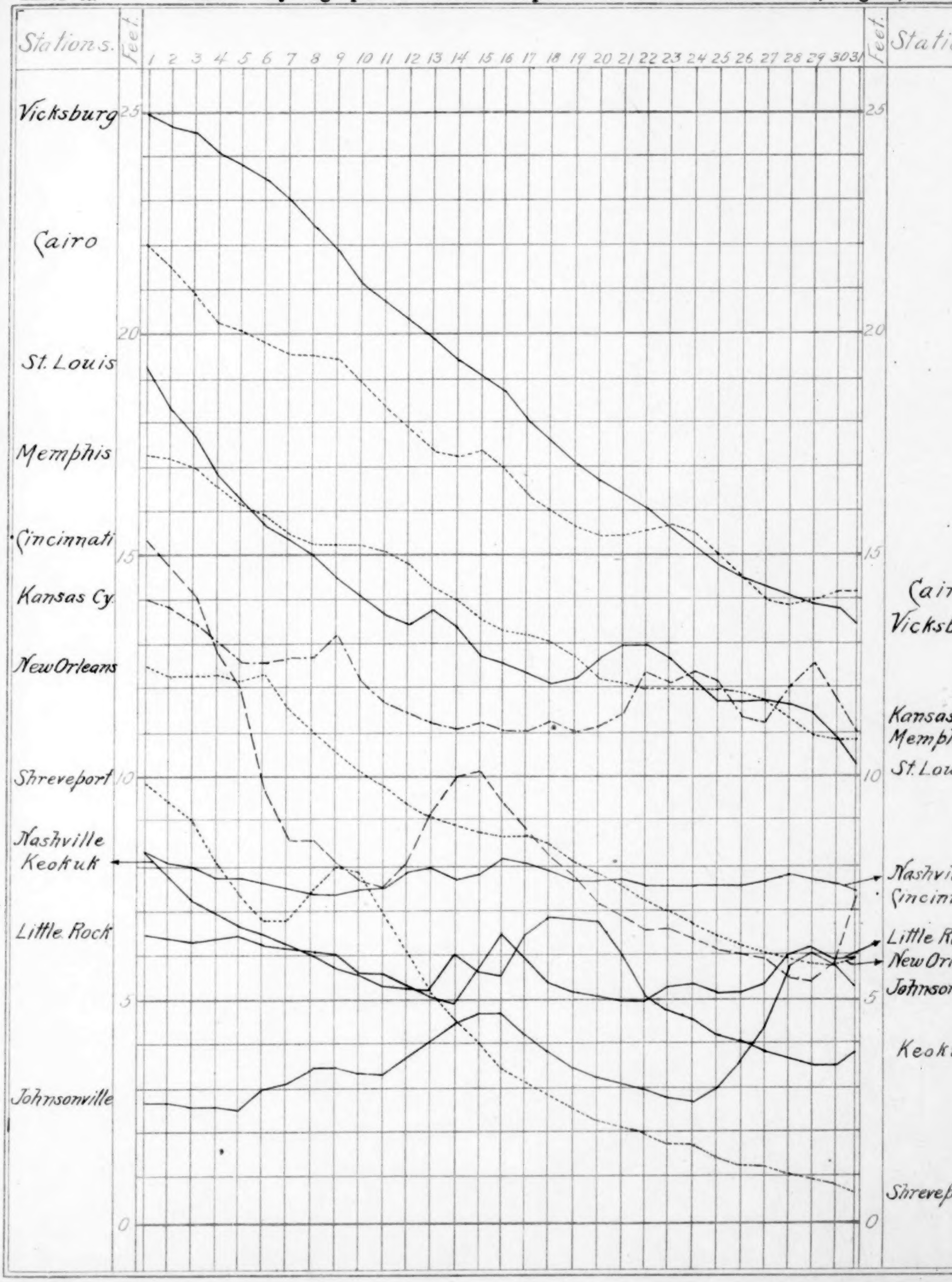


Chart II. Tracks of Centers of High Areas, August, 1908.

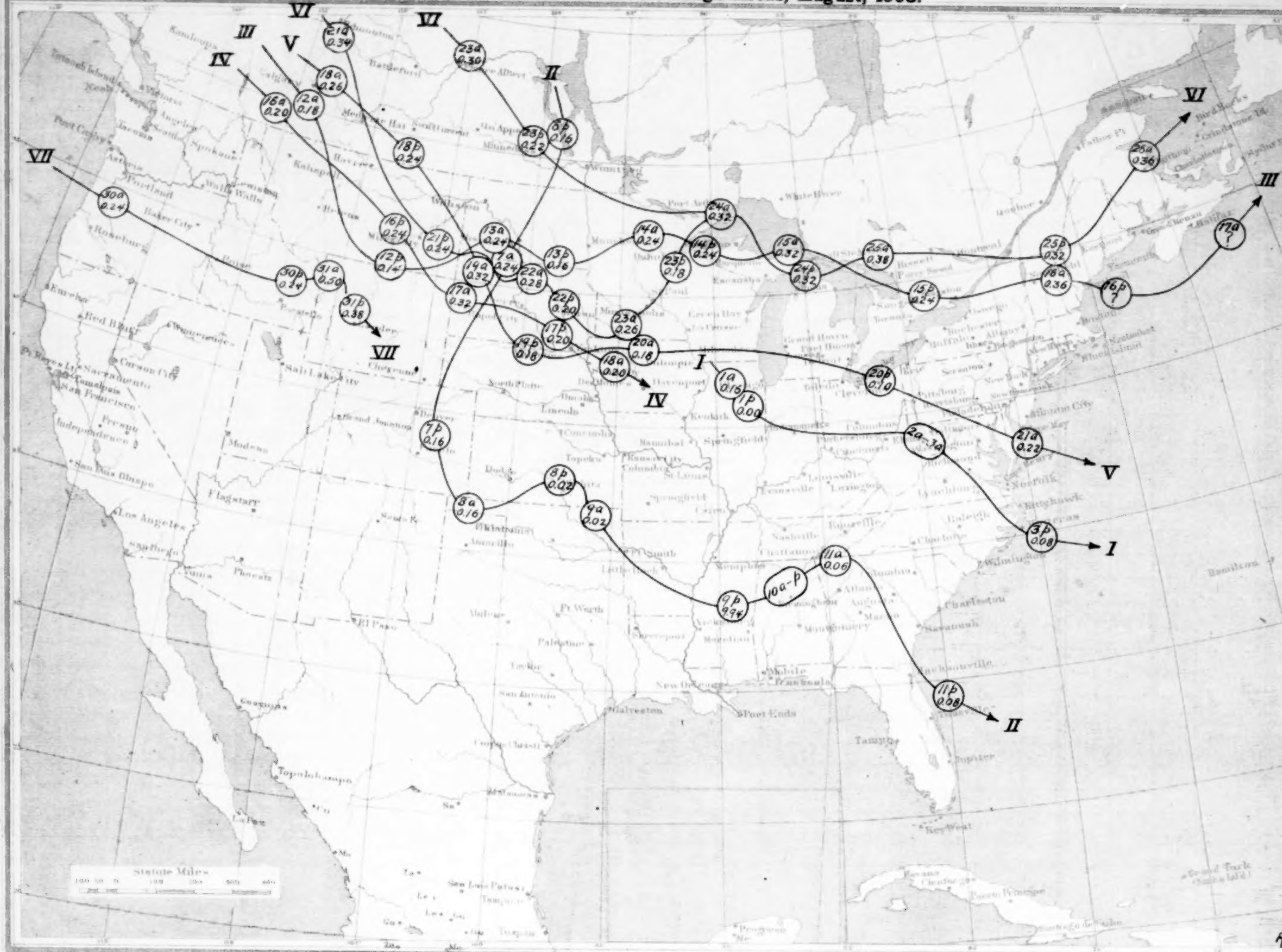


Chart III. Tracks of Centers of Low Areas, August, 1908.

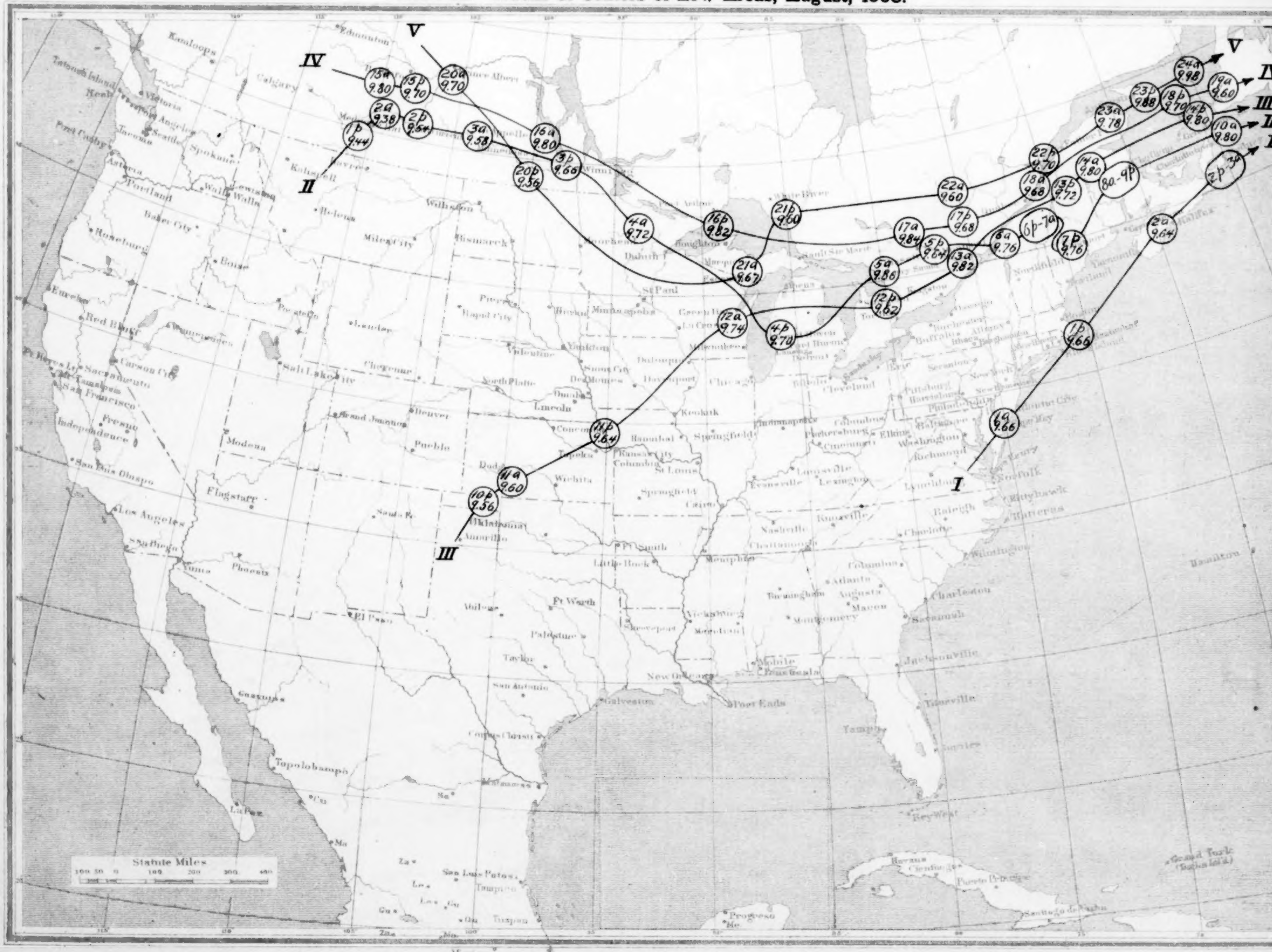


Chart IV. Total Precipitation, August, 1908.

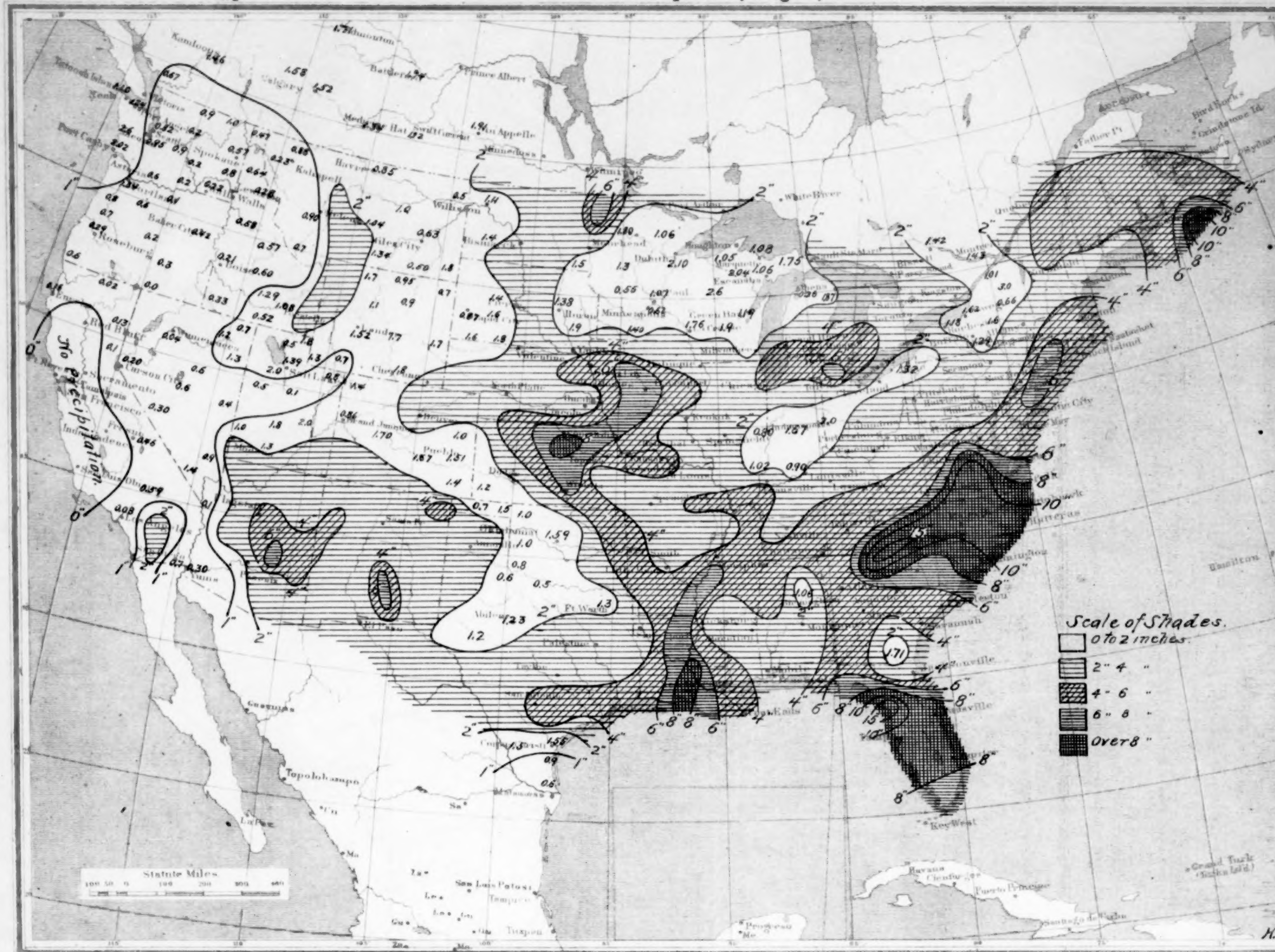


Chart V. Percentage of Clear Sky between Sunrise and Sunset, August, 1908.

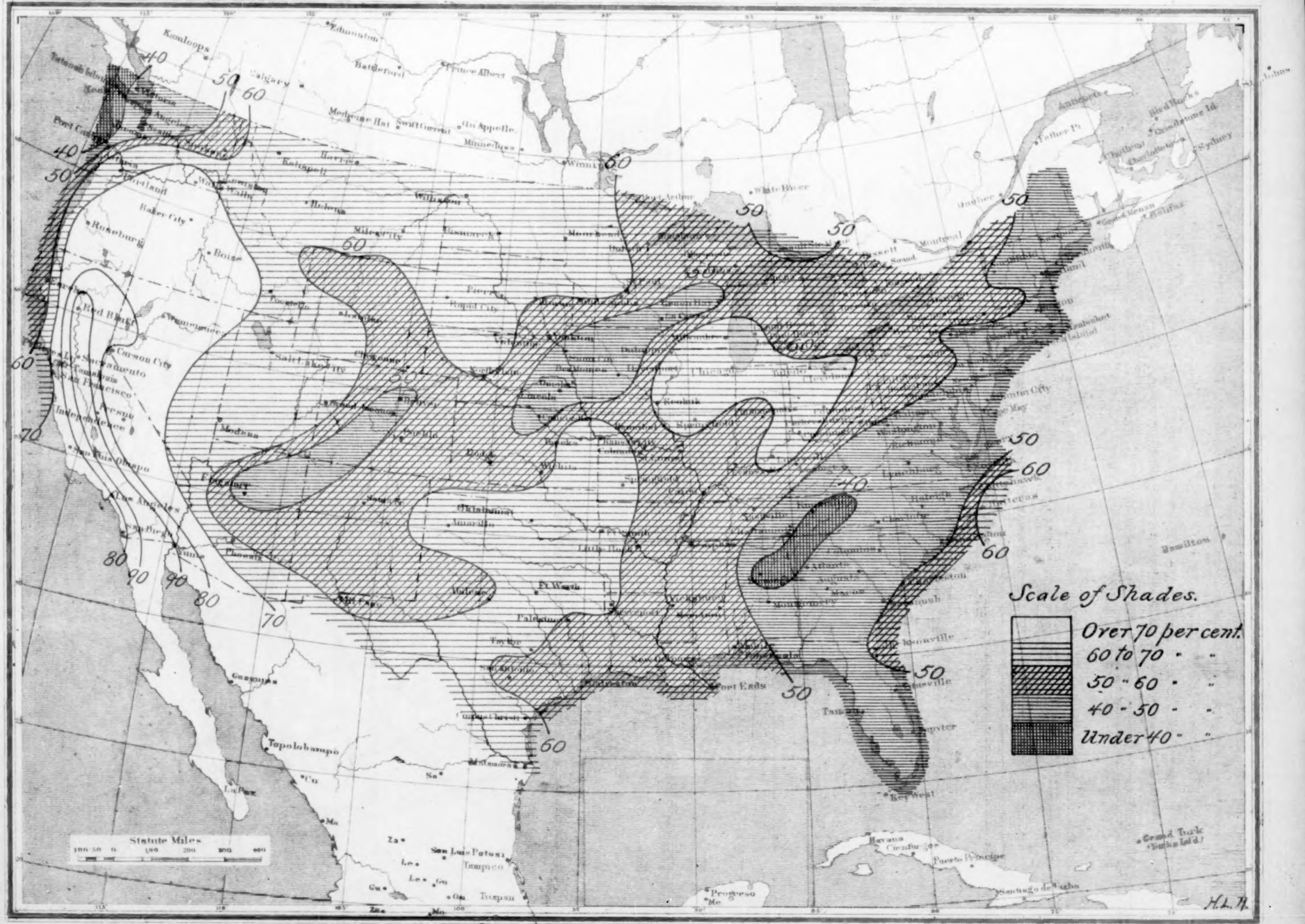
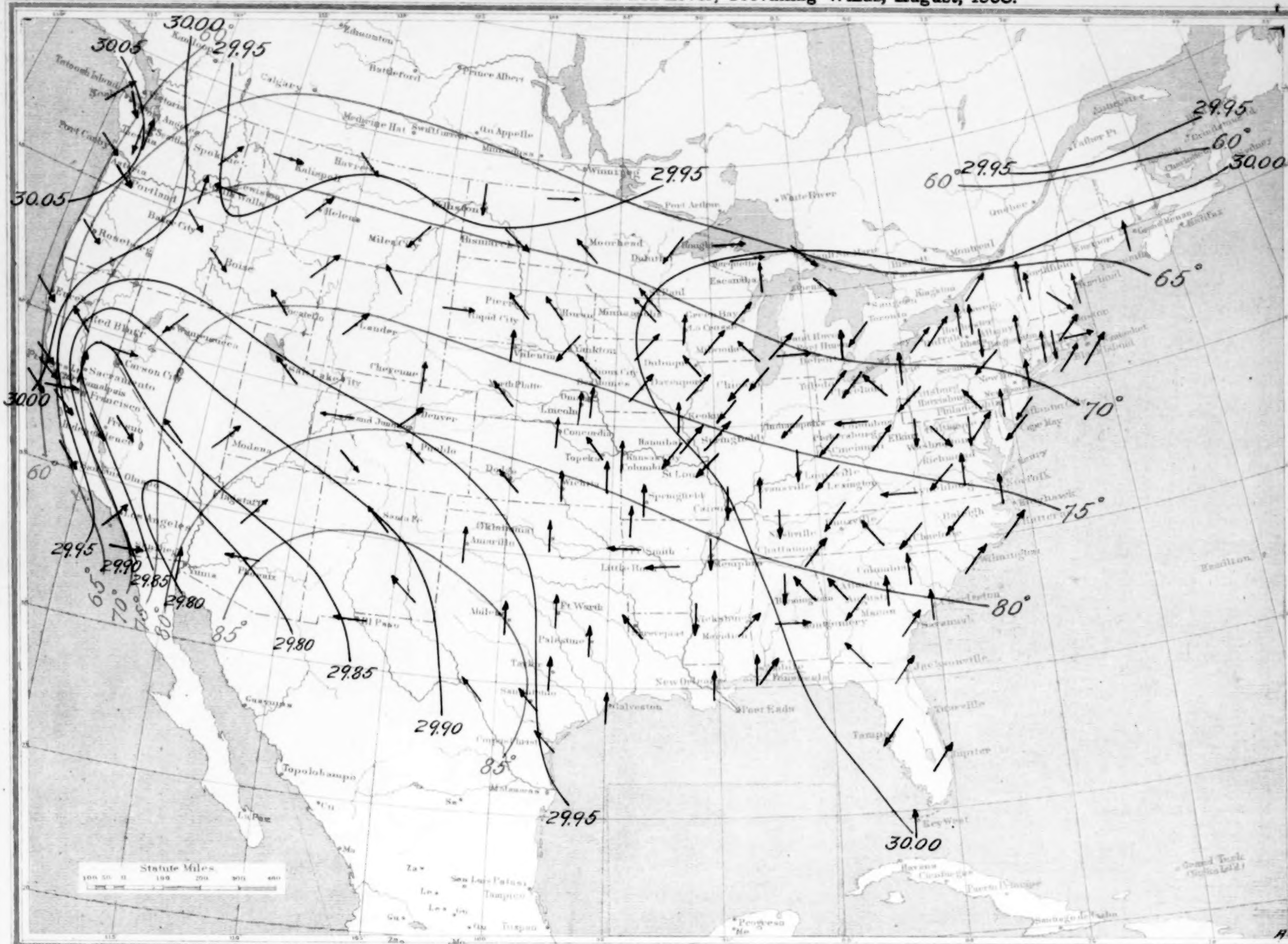


Chart VI. Isobars and Isotherms at Sea Level; Prevailing Winds, August, 1908.



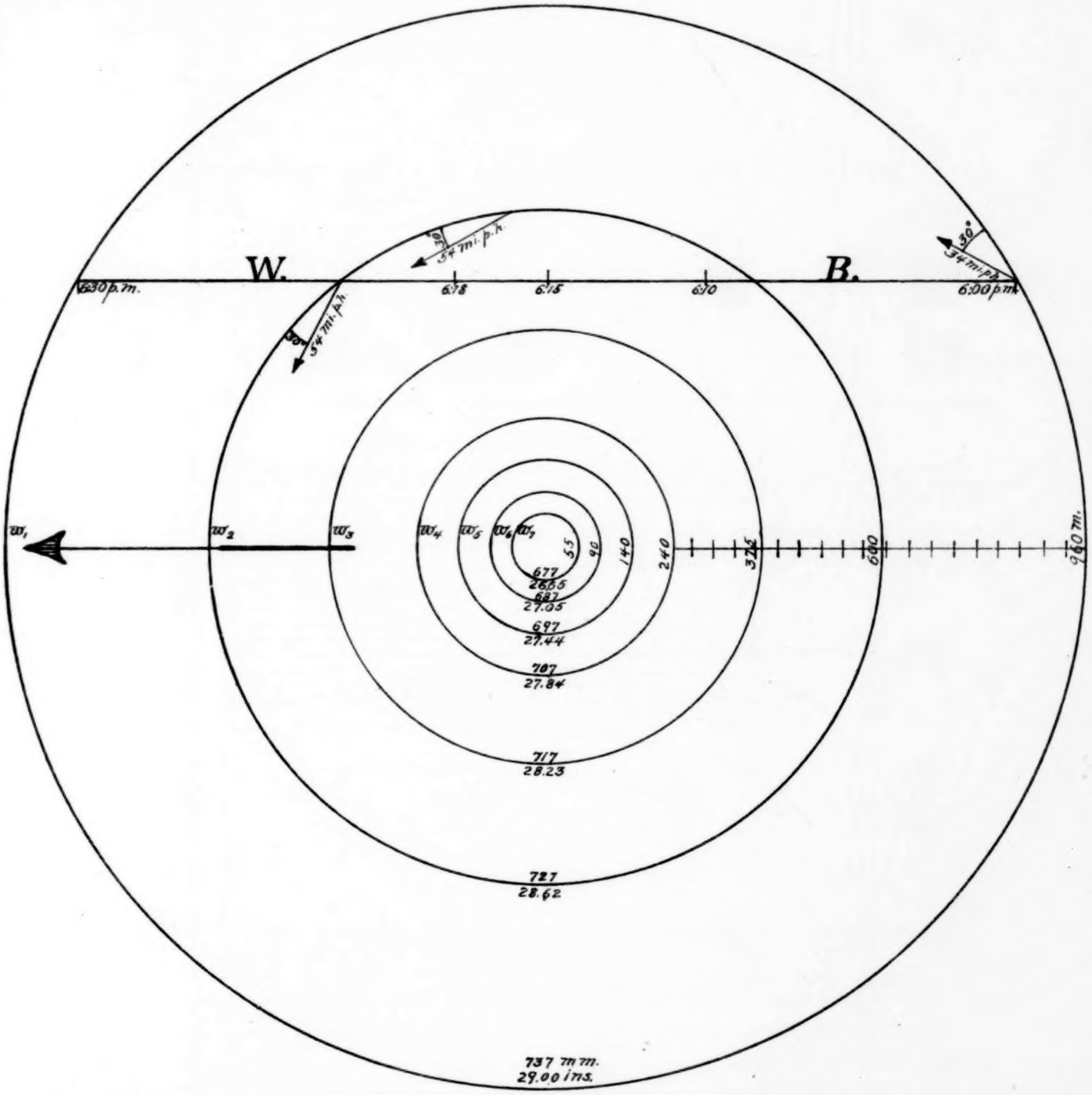


Fig. 6.—Horizontal section of the St. Louis, Mo., tornado of May 27, 1896, showing the distribution of pressure and the wind vectors.
W. B.—locus of the U. S. Weather Bureau station with reference to the vortex.
Scales: Linear, 1 division=40 meters.
Time, 1 division=0.7 minute.

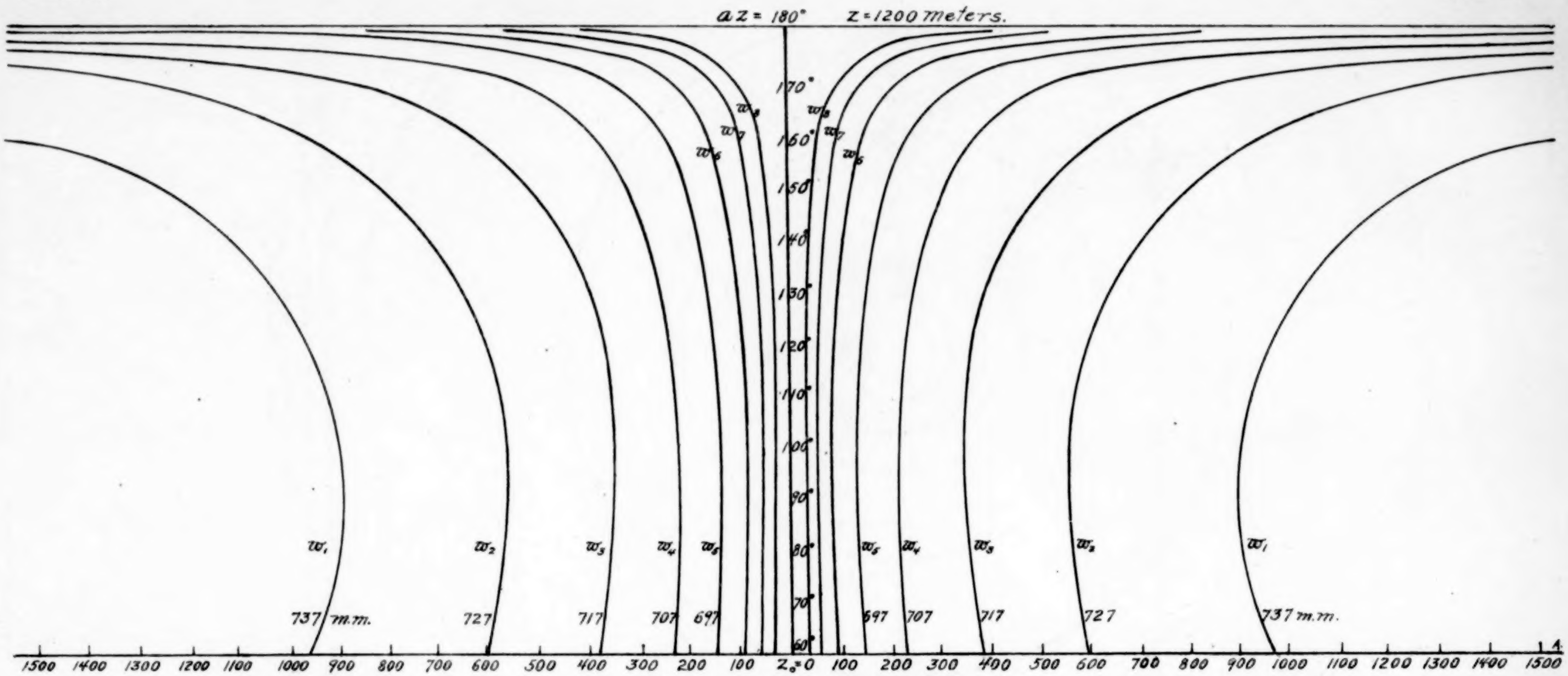


Fig. 7.—Vertical section of the St. Louis, Mo., tornado of May 27, 1896, showing the vortex tubes, $\varpi_1 \ldots \varpi_8$, in a truncated, dumbbell-shaped vortex. (Constructed from Table 37.)

STORM AND HURRICANE WARNINGS.

STORM HURRICANE

Northeasterly winds. Southeasterly winds. Northwesterly winds. Southwesterly winds. Hurricane warning.

EXPLANATION.

Storm-warning Flags.—A red flag, with a black center, indicates that a storm of marked violence is expected.

The pennants displayed with the flags indicate the direction of the wind: red, easterly (from northeast to south); white, westerly (from southwest to north). The pennant above the flag indicates that the wind is expected to blow from the northerly quadrants; below, from the southerly quadrants.

By night a red light indicates easterly winds, and a white light below a red light, westerly winds.

Hurricane Warning.—Two red flags, with black centers, displayed one above the other, indicate the expected approach of tropical hurricanes, and also of those extremely severe and dangerous storms which occasionally move across the Lakes and northern Atlantic coast.

Hurricane warnings are not displayed at night.

CANADIAN STORM SIGNALS.

DAY SIGNALS.

Day signal.	If displayed on Lakes Superior, Erie, or Ontario indicates—	If displayed on Lake Huron or in Georgian Bay indicates—
No. 1.......	A moderate gale is expected at first from an easterly direction.	A moderate gale is expected at first from a southerly direction.
No. 2.......	A moderate gale is expected at first from a westerly direction.	A moderate gale is expected at first from a northerly direction.
No. 3.......	A heavy gale is expected at first from an easterly direction.	A heavy gale is expected at first from a southerly direction.
No. 4.......	A heavy gale is expected at first from a westerly direction.	A heavy gale is expected at first from a northerly direction.

The cone, when displayed alone, indicates that it is expected that the wind will attain a velocity of 25 miles an hour, but will not exceed 35 miles, and it is not intended to indicate that an ordinary well-found vessel should stay in port, but is simply a warning that strong winds are expected from the quarter indicated.

The drum will always be hoisted when the velocity of the wind is expected to exceed 35 miles an hour.

NIGHT SIGNALS.

The Night Signal corresponding to Day Signals Nos. 1 and 3 is a red light.

The Night Signal corresponding to Day Signals Nos. 2 and 4 is a white light above a red light.